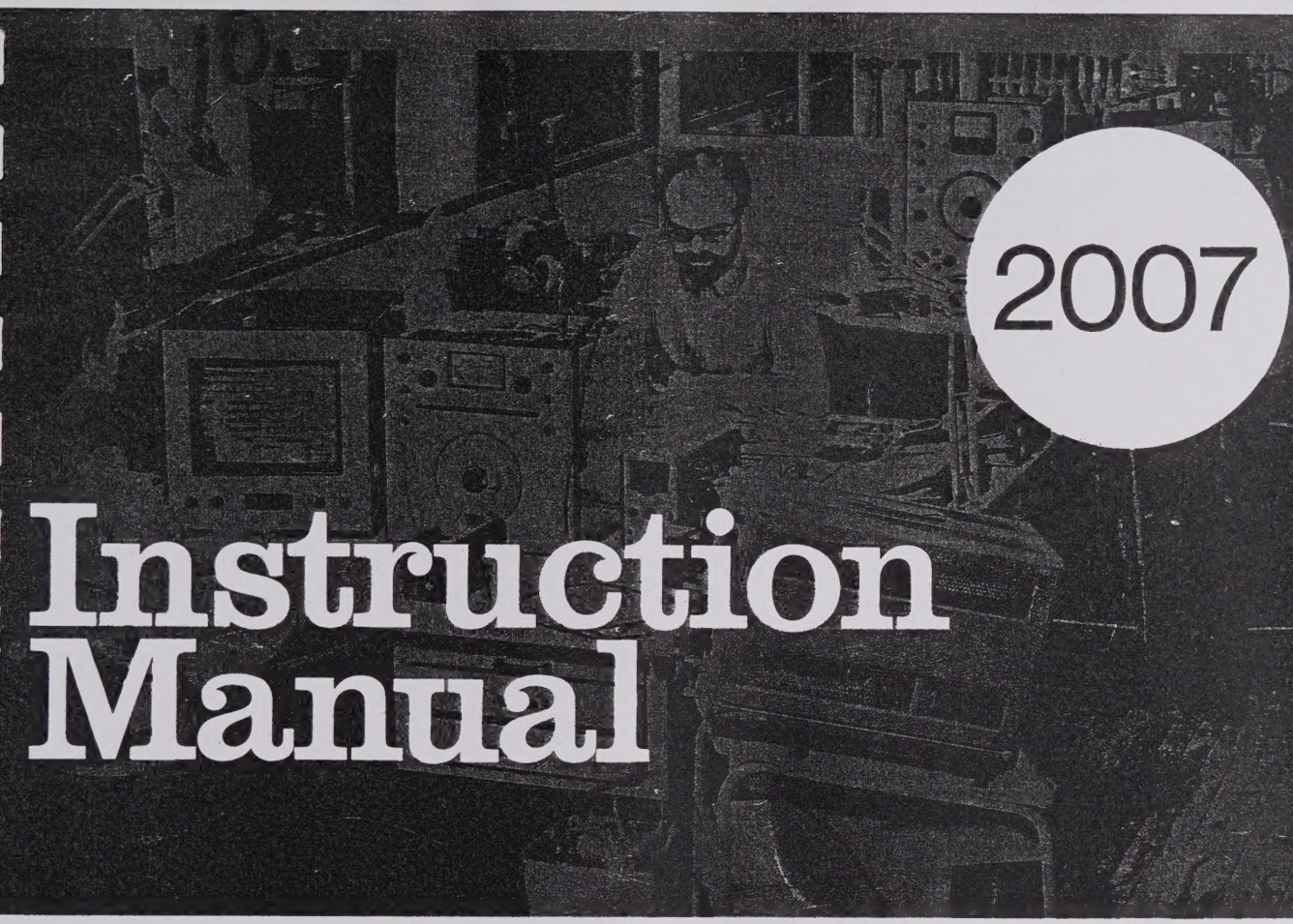


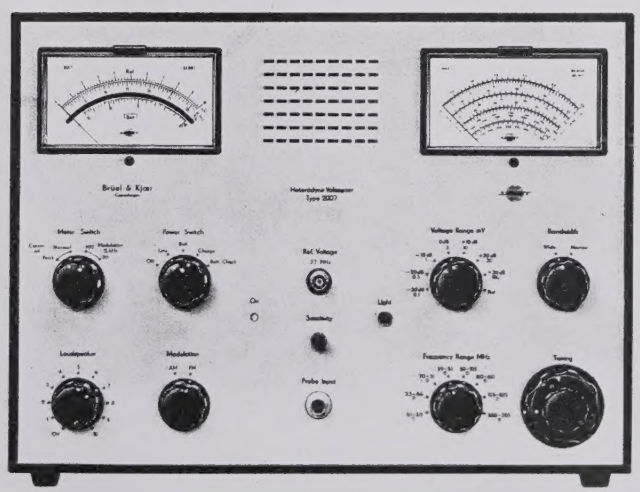
2007

Instruction Manual

Heterodyne Voltmeter Type 2007

A portable, mains or battery operated instrument with voltage ranges from 10 μV to 100 V, covering the 100 kHz to 305 MHz frequency range for barrier or modulation measurements on AM or FM signals.

Features include a peak diode detector for TV measurements, manual or remote voltage controlled frequency tuning, a built in loudspeaker for easy signal identification and self-contained echargeable batteries and charger.



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HETERODYNE VOLTMETER
TYPE 2007

(Applicable to instruments after Serial No. 395364)

March 1973

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type 2007

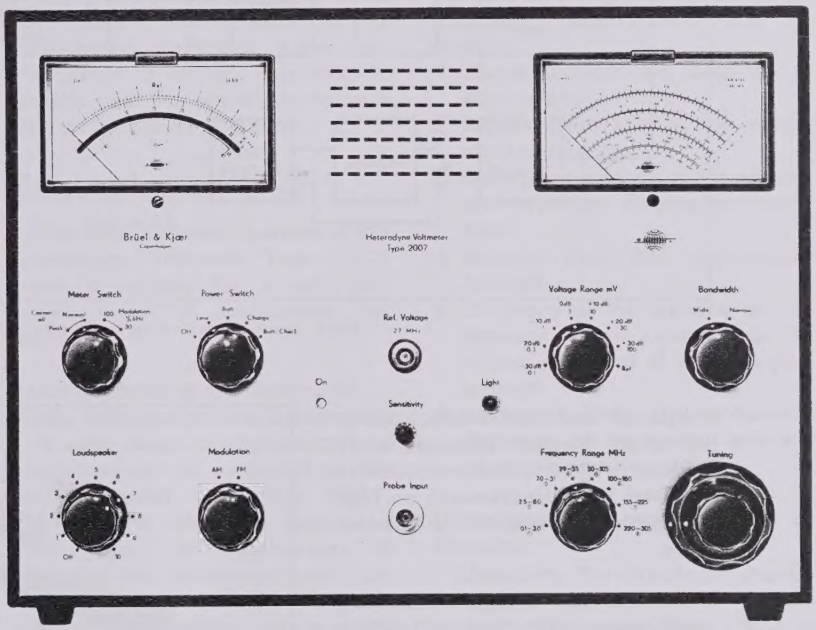
Frequency-Selective Precision RF Voltmeter

FEATURES:

- Frequency range 100 kHz to 300 MHz
- Voltage range 10 μV to 100 V
- Direct reading of AM and FM modulation in % and kHz
- AGC for modulation measurement
- Greater than 50 dB image and intermediate frequency rejection in all ranges
- Peak detector for measurement of TV signals
- Easy calibration
- Built-in loudspeaker for signal identification
- High impedance input probe
- Portable, completely selfcontained
- AC mains; built-in rechargeable batteries and charger; or external batteries

USES:

- Testing and fault finding of radio communication equipment
- Measurements of antenna distribution and transmission line systems
- Proof of performance tests
- Measurement of output voltages of signal and harmonic generators and synthesizers
- Measurements on TV transmitters and receivers
- Field strength meter calibration
- Field strength and stray radiation measurements with suitable antennae



The Heterodyne Voltmeter Type 2007 is a portable, completely self-contained, precision instrument designed to measure voltages in AM-FM, and television frequency ranges. It will determine the voltage level, the frequency, and the modulation of an input signal.

The advanced solid state circuitry and compact design make the Heterodyne Voltmeter an extremely versatile instrument for performing a wide range of selective RF voltage measurements. The design, capability, and precise performance make it ideal for application to nearly every voltage measuring need, ranging from antenna measurements in a multi-storey apartment block to radio communication measurements in a spacecraft.

The Heterodyne Voltmeter features a compact, rugged construction. Its weight and size establish the instrument as a completely portable package, comparable to a standard attache case.

Description

The tuned-in frequency is indicated on a meter scale. Another meter indicates the amplitude of the measured RF voltage and the modulation. A built-in loudspeaker provides an audible signal check. Fig.1 shows a simplified block diagram of Type 2007.

Input Probe

The input to the Heterodyne Voltmeter is via a small probe connected to the instrument by a 1.2 m (4 feet) multicore cable. The probe contains an FET stage and features the advantages of high input impedance providing minimum loading of the circuit being

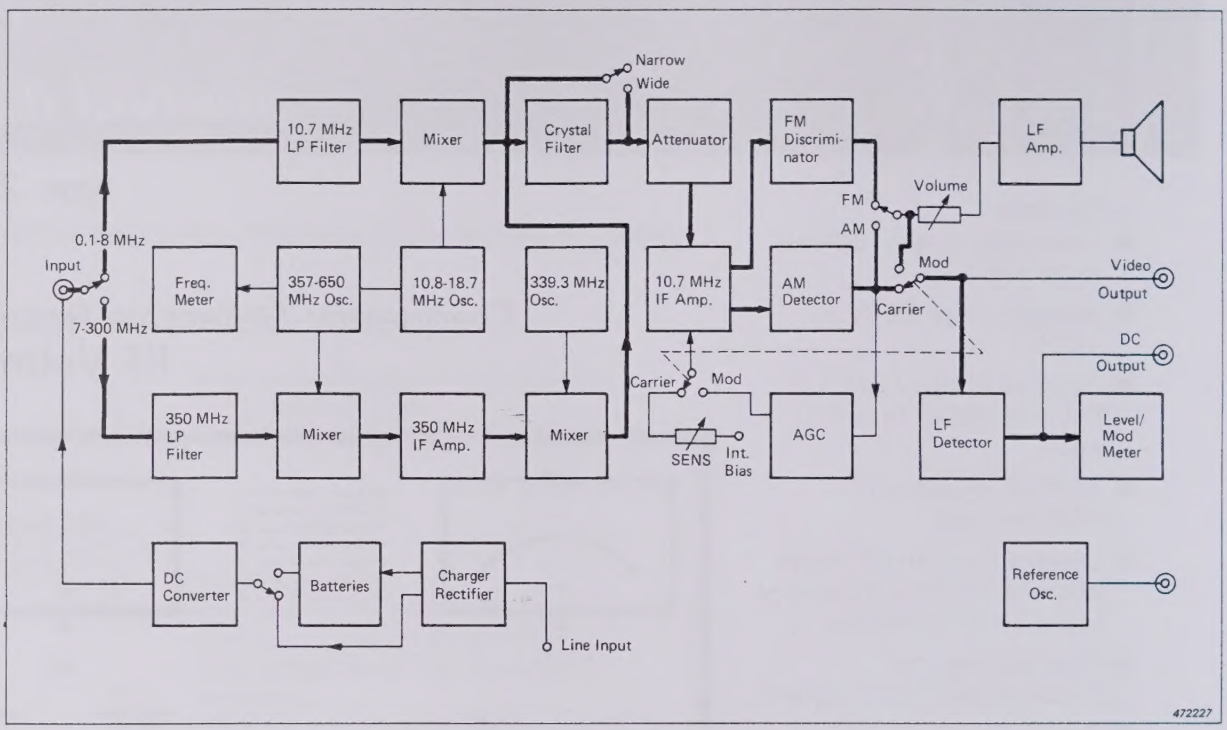


Fig.1. Block diagram of the Heterodyne Voltmeter Type 2007

measured, and easy handling due to its small physical dimensions. In addition a 50 Ω probe extension is included for measurements on high frequency transmission line terminations.

The normal voltage measuring range covers 100 μV to 100 mV full scale deflection. A capacitive voltage divider is provided which when fitted to the input probe, extends the range to 100 V. The attenuation is 60 dB, and the input capacitance is as low as 2 pF. In Fig.2 is shown the input probe, the 60 dB attenuator, and the different adaptors supplied with the Heterodyne Voltmeter.

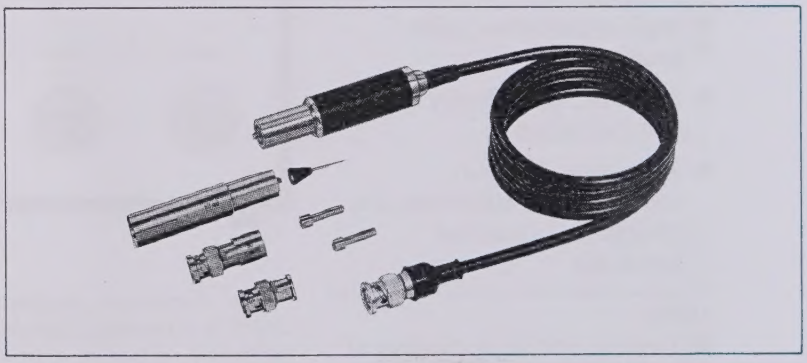


Fig.2. Input probe, 60 dB attenuator, 50 Ω termination and various adaptors

Input Circuitry

The Heterodyne Voltmeter Type 2007 has been designed with an untuned input and a mixer circuit with an ultra flat frequency response. With the normal type of instrument having a tunable input, recalibration is necessary at each frequency due to the corresponding "Q" changes. However, the B & K Type 2007 establishes self-calibration from a built-in stabilized 27 MHz reference voltage oscillator. After calibration, further adjustments are not necessary while sweeping the entire frequency range from 100 kHz to 300 MHz.

Frequency Selective Section

The frequency selective part of Type 2007 is a superheterodyne receiver with electronic control of the variable oscillator. Remote control is possible. In the two frequency ranges covering 0.1 to 8 MHz an IF frequency of 10.7 MHz is used. In the frequency ranges covering 7 to 300 MHz a triple-detection receiver is used having IF frequencies of 350 MHz and 10.7 MHz for the double conversion. This design provides greater image-frequency discrimination and better adjacent-channel selectivity than ordinary super-heterodyne receivers. Type 2007 gives more than 50 dB image-frequency and intermediate frequency rejection.

A crystal filter following the mixer stage provides a "narrow" measurement bandwidth of ± 1 kHz. By switching out this filter a "wide" bandwidt of ± 100 kHz is obtained.

Read-out Indicators

The Heterodyne Voltmeter has a versatile read-out system, featuring

three major output indicators: a dual function meter for voltage level and modulation, a frequency indication meter, and a built-in loudspeaker.

RF Voltage and Modulation Meter

The voltage and modulation meter uses the same scale for measurement. The modulation ranges are 0 to 30 and 0 to 100, kHz and %, the seven voltage ranges are arranged in a 1, 3, 10 sequence.

The narrow bandwidth of the instrument makes possible very accurate FM modulation measurements according to the carrier disappearance method. To ensure reading accuracy the meter has a mirror back to prevent parallax. A peak detector is built-in for TV measurements.

Frequency Meter

The frequency tuning covers a 100 kHz to 300 MHz range in eight overlapping bands: 0.1 to 3 MHz, 2.5 to 8 MHz, 7 to 31 MHz, 29 to 55 MHz, 50 to 105 MHz, 100 to 160 MHz, 155 to 225 MHz and 220 to 300 MHz. To aid quick and accurate frequency selection, the tuning is performed by a pair of coarse and fine resolution potentiometers placed concentrically.

The tuned-in frequency is indicated on a moving coil meter provided with interchangeable scales. Three scales are included, a general frequency scale, a scale for American TV channels, and one for European TV channels. Scales can be custom made to order.

Built-in Loudspeaker

For audible assistance the Heterodyne Voltmeter is equipped with a built-in loudspeaker which permits the operator to listen to the carrier modulation characteristics of the incoming signal. Parameters and discrepancies such as distortion, type of modulation, deviations, and drift can be noted from the speaker.

In addition, the speaker assists in accelerating measuring operations by providing an audible source for identifying and tuning-in an unknown signal. Once the sensitivity is established, the mode switch is turned to the modulation position, and the percentage is read directly from the RF and Modulation Meter.

Power Supply

The Heterodyne Voltmeter Type 2007 is completely self-contained. A rechargeable set of nickel cadmium batteries and a charger are built-in. The instrument can also be powered from any line voltage from 100 to 240 V AC, and any line frequency from 50 to 400 Hz. Power inputs are further included for operating from a 5 to 7 V DC external source and battery charging from 12 V DC supply.

The meter scale illumination is continuous when the instrument is driven from an AC power line. To save battery, the meter lamps are push-button controlled when the instrument is battery operated. To aid the user the power-on indicator flashes for battery operation.

Examples of Use

The comprehensive features of the Heterodyne Voltmeter Type 2007 make it suitable for a wide and varied range of applications, for example:

Trouble-Shooting and Testing of Radio Communications Equipment

A wide range of communications equipment can be measured quickly and accurately with Type 2007. Many of the difficulties associated with repair and calibration of receivers are eliminated with this instrument. Such measurement problems as trimming stagger-tuned IF's, stage gain, and adjusting the proper frequency from the local oscillator are but a few of the RF selective readings that the instrument will perform. Type 2007 is further particularly suited to production testing and adjustment of television and radio subassemblies such as tuners, IF amplifiers, RF amplifiers and preamplifiers.

Antenna Distribution Systems

Antenna distribution systems and RF amplifiers for radio and television signals can be accurately measured with the Heterodyne Voltmeter Type 2007. The instrument's portability and unique electrical features make it ideal for this application. A typical system is shown in Fig.3. With the use of the Heterodyne Voltmeter, the following measurements can be made:

1. Signal strength and cross talk at each outlet.
2. Transmission loss in the cables and terminations.
3. Gain and response of the primary and secondary distribution amplifiers.
4. Isolation from local interference sources.
5. Efficiency of the antenna can be determined by measuring its output in a field of known signal strength.
6. Harmonic and intermodulation distortion of the system and any of its components.

Directional Characteristics of an Antenna

Measuring the directional characteristics of an antenna is accomplished quickly with Type 2007 in combination with the Level Recorder Type 2305 or 2307 and the Turntable Type 3921. The characteristics are recorded in the form of a polar plot.

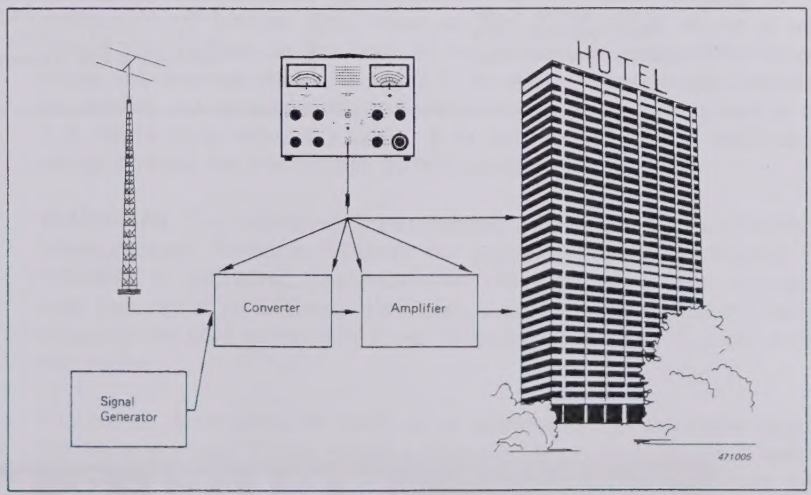


Fig.3. Measurements of antenna distribution systems

Specifications 2007

Frequency Ranges:
100 kHz to 300 MHz in 8 ranges:
1. 0.1 to 3 MHz.
2. 2.5 to 8 MHz.
3. 7 to 31 MHz.
4. 29 to 55 MHz.
5. 50 to 105 MHz.
6. 100 to 160 MHz.
7. 155 to 225 MHz.
8. 220 to 300 MHz.

Voltmeter Ranges:
Full scale deflection for:
0.1, 0.3, 1, 3, 10, 30 and 100 mV without 60 dB attenuator.
0.1, 0.3, 1, 3, 10, 30 and 100 V with 60 dB attenuator.

Input Impedance:
3 MΩ//6 pF at 1 MHz.
4 kΩ//6 pF at 200 MHz
With 60 dB attenuator connected the impedance is greater than 10 kΩ//2 pF at all frequencies.

50 Ω Termination:
Standing wave ratio is better than 1:1.2.

Intermediate Frequency:
Ranges 1 and 2: 10.7 MHz.
Ranges 3, 4, 5, 6, 7 and 8: 350 MHz and 10.7 MHz.

Image-Frequency Rejection:
More than 50 dB.

IF Rejection:
More than 50 dB.

Bandwidths:
Wide: ± 100 kHz for measurements at frequencies > 3 MHz.
Narrow: ± 1 kHz for measurements at frequencies < 3 MHz.

Frequency Accuracy:
Ranges 1 and 2: 1% ± 100 kHz
Ranges 3, 4, 5, 6, 7 and 8: 1% ± 1 MHz.

Voltage Accuracy:
0.1 to 100 MHz: ± 1 dB
100 to 200 MHz: ± 2 DB
200 to 300 MHz: ± 3 dB

Modulation Accuracy:
5% of full scale deflection (1000 Hz) at wide bandwidth.
± 0.5 dB for 30 Hz to 8 kHz, 40% AM modulation.
± 0.5 dB for 30 Hz to 40 kHz,
± 40 kHz FM modulation.

RF and Modulation Meter:
Mirrored scales for accurate reading.
Voltage scales calibrated from —10 to + 10 dB, 0 to 1 V and 0 to 3.2 V.
Modulation scales:
0 to 30 and 0 to 100, % AM and kHz FM

Frequency Meter:
Indicates the tuned-in frequency. The scale can be quickly changed. Three scales included. Scales can be custom made to order.

Meter Scale Illumination:
Continuous when mains operated, push-button control when battery operated.

Audible Signal Identification:
Built-in loudspeaker to be used for both AM and FM measurements.

Reference Voltage:
27 MHz from built-in oscillator.
The reference voltage is stabilized to better than 2% from 0 to 50°C, better than 1% for ± 10% change in mains voltage.

Inherent Noise:
Less than 2.5 μV in narrow bandwidth mode.

Distortion, typical:
1% at 31.5 mV input.
0.1% at 4.0 mV input.

Temperature Range:
5° to 40°C (41° to 104°F).

Power Supply:
The instrument can be operated from:

1. Built-in Ni-Cd batteries, line or battery operated charging unit included.
2. 100— 115— 127— 150— 220— or 240 V AC, 50 to 400 Hz, automatic recharging of built-in batteries.
3. 5 to 7 V external DC source.
4. 12 V external DC source for recharging.

Instrument "on" lamp flashes for battery operation.

AC power consumption is less than 18 W. Scale illumination uses 6 W approx., recharging unit 5 W approx.

Operating time of built-in batteries: 8 hours approx.

Charging time for totally discharged batteries: 16 hours approx.

Cabinet:
Supplied as model A (light-weight metal cabinet), B (model A in mahogany cabinet) or C (as A but with flanges for standard 19" racks).

Dimensions (model A):
Height: 280 mm (11 in)
Width: 380 mm (15 in)
Depth: 150 mm (6 in)

Weight:
2007 A: 10 kg (11 lb).
2007 B: 13 kg (29 lb).
2007 C: 11 kg (24 lb).

Accessories Included:
1 Input Probe ZC 0008
1 Attenuator (—60 dB) ZF 0003
1 50 Ω termination (BNC) RZ 0006
2 Blunt nose Prod. JL 0029
1 Needle nose Prod. UA 0124
1 BNC connector JP 0029
1 7-pin DIN plug JP 0703
1 Frequency scale SA 0155
1 Scale for American TV channels SA 0156
1 Scale for European TV channels SA 0157
1 Power cord
Various fuses and lamps
1 Protection Cover FE 0002

Accessories Available:
75 Ω Termination (BNC) WG 0001.
Special frequency scales can be custom made to order.
Custom modifications available.

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2. CONTROLS

2.1. MEASUREMENT PROBE AND PROBE ACCESSORIES

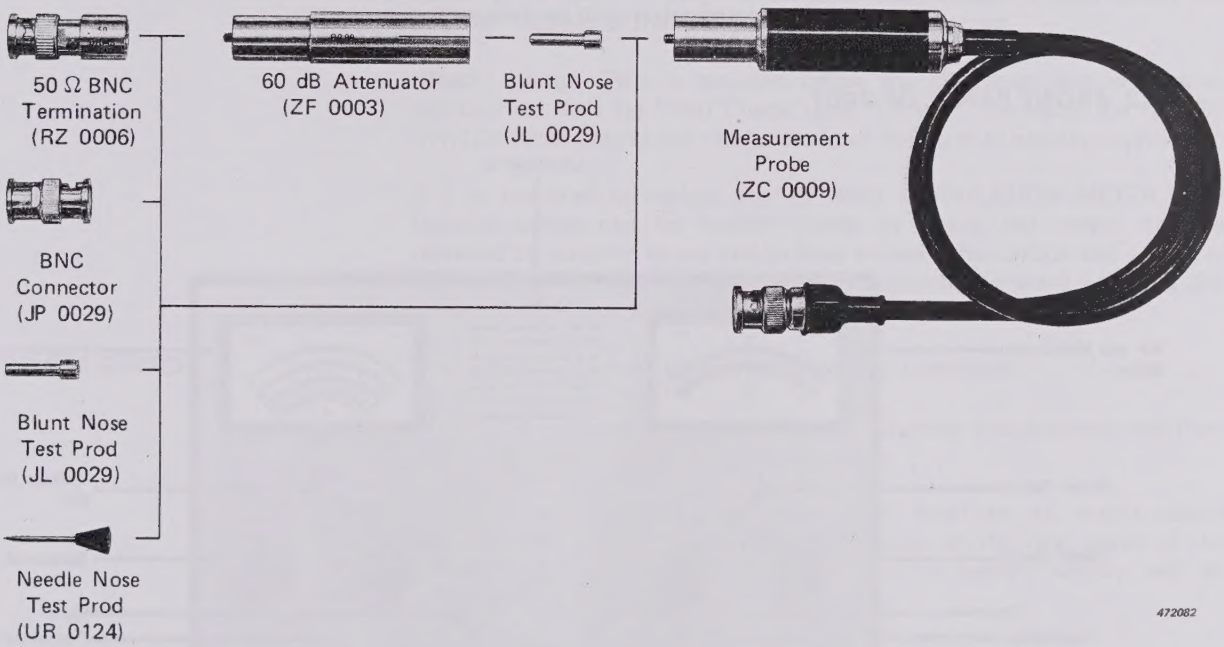

Fig.2.1. Measurement Probe and probe accessories of the 2007

MEASUREMENT PROBE:

The Measurement Probe CZ 0009 contains a high input impedance field effect transistor preamplifier to prevent loading of the measurement source. The input to the preamplifier is via a screw thread termination on the body of the probe and accepts the range of probe accessories shown in Fig.2.1. To allow in situ measurements to be carried out on electronic apparatus, the output of the probe is via a 1.2 metre long screened cable. It is terminated with a BNC output, which directly fits the PROBE INPUT socket of the 2007.

WARNING. The maximum input voltage which may be handled by the Measurement Probe is 100 mV for signal frequencies ranging from 100 kHz to 300 MHz. The maximum DC bias which may be applied with the signal is 500 volt. However, extreme care should be taken in applying the bias to the 2007, as, if applied suddenly, it could damage the probe.

60 dB ATTENUATOR:

The 60 dB Attenuator ZF 0003 is for attenuation of the input signal to the Measurement Probe, thereby changing the maximum input voltages marked around the VOLTAGE RANGE switch of the 2007 from mV to

volts. The input to the attenuator is a screw thread termination, which accepts the range of probe accessories shown in Fig.2.1. The attenuator push fits onto the body of the Measurement Probe when the screw thread input termination has been fitted with a Blunt Nose Test Prod Type JL 0029 (see Fig.2.1).

50 Ω TERMINATION:

The 50 Ω BNC Termination RZ 0006 screws directly onto the input of the Measurement Probe or 60 dB Attenuator. It is used to match the input of the Probe or Attenuator to a 50 Ω measurement source.

WARNING. When using the 50 Ω Termination, the maximum input voltage is limited to 3.5 volts. This should not be exceeded as the termination will be damaged.

2.2. FRONT PANEL OF 2007

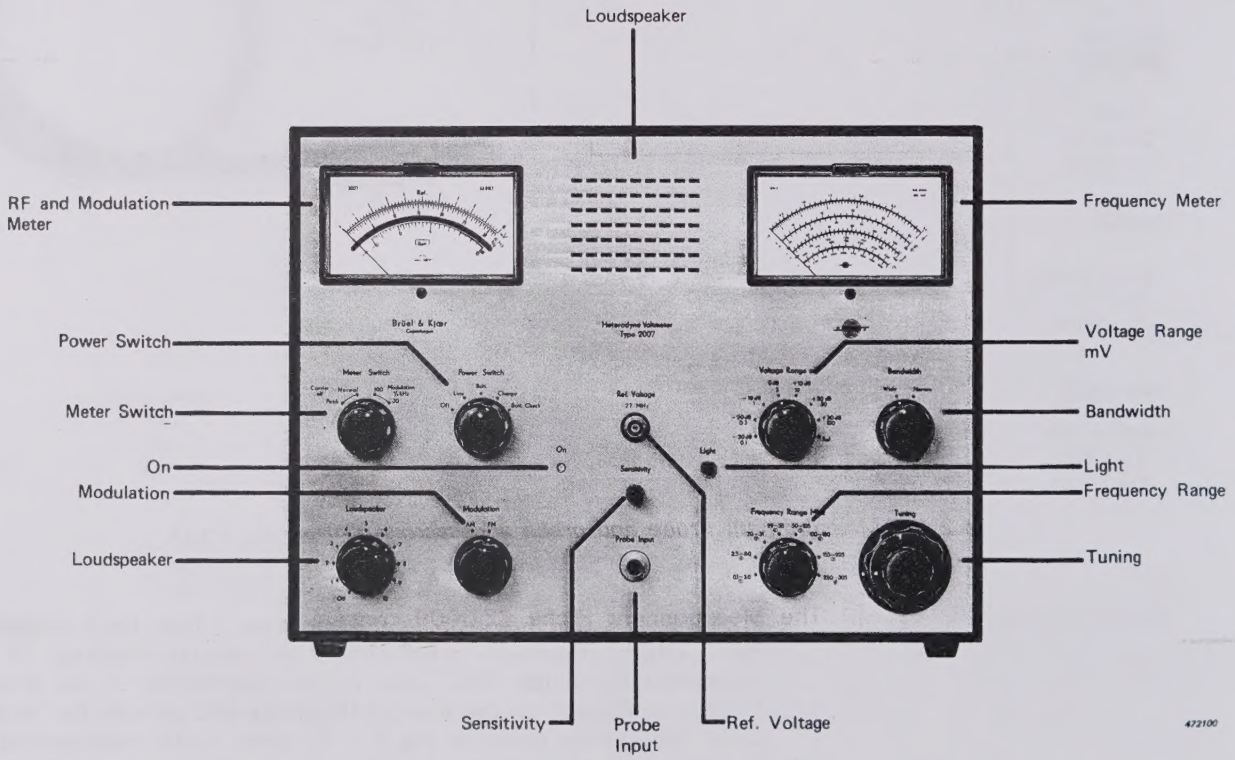

Fig.2.2. Front panel of the 2007

RF AND MODULATION METER:

A moving coil indicating meter with mirrored back to help reduce parallax errors. The meter is fitted with the interchangeable scale SA 0167, which has the following ranges:

Voltage and Modulation Ranges. These are situated immediately above the mirror and are calibrated from 0 to 10 and 0 to 31.5. For voltage measurements using these ranges the "Carrier" modes of the METER SWITCH have to be selected. The value corresponding to full scale deflection is given by the setting of the VOLTAGE RANGE switch. The units of the range calibration are then given in mV, if the signal to

be measured is applied directly to the Measurement Probe input, or in volts if applied via the 60 dB Attenuator.

For modulation measurements using these ranges the appropriate "Modulation" mode of the METER SWITCH has to be selected. The units of the range calibration are in % modulation for amplitude modulated signals or in kHz frequency deviation for frequency modulated signals.

dB range. This is situated immediately below the mirror and is calibrated from —10 to + 10 dB, where + 10 dB corresponds to full scale. It is used in conjunction with the voltage ranges when the "Carrier" modes of the METER SWITCH are selected.

"Batt" Range. This is situated below the dB range and is used in conjunction with the "Batt Check" and "Charge" modes of the POWER SWITCH for checking the charge state of the built-in battery supply.

If it is required to replace the RF AND MODULATION METER scale (special scales can be custom made to order) the meter may be released by pushing down and pulling forward the central clip on top of the meter. The meter should then tilt slightly forward enabling the scale to be slid out for a new scale to be inserted.

POWER SWITCH: Five position switch with the following functions:

"Off". The internal and external power supplies are disconnected from the internal supply lines of the instrument.

"Line". The instrument may be powered from an AC mains supply connected to the AC POWER INPUT socket on the rear panel of the instrument. At the same time the built-in battery supply will be automatically charged.

"Batt". The instrument is powered from the built-in battery supply (see section 3.1.2). The instrument may also be powered from a 5.6 to 7.0 volt battery connected externally to the AUXILIARY OUTPUT socket (see section 3.4.4) on the rear panel.

"Charge". The measurement circuitry is disconnected and the built-in battery supply is connected to the instrument's AC to DC converter for recharging from a mains supply, which may be connected to AC POWER INPUT socket. For totally discharged batteries the recharge time is approximately 16 hours.

"Batt. Check". This mode is used to check whether the built-in batteries are charged. If charged, the needle of the RF AND MODULATION METER should deflect to within the "Batt" region at the bottom of the meter scale.

ON: A neon indicator lamp which lights when the "Line" and "Batt." modes of the POWER switch are selected, and the measurement circuitry of the instrument is powered using internal or external power supplies. In the "Line" mode the lamp will light continuously, whilst in the "Batt." mode the lamp will flash at regular intervals.

METER SWITCH:

This switch governs the measurement mode of the RF AND MODULATION METER. It is used in conjunction with the MODULATION switch and has four modes:

"Carrier Peak". With this mode selected, amplitude measurements on the video carriers of TV signals may be made using the voltage and dB scales of the RF AND MODULATION METER. It should be noted that the meter indicates the RMS level of the carrier, not the peak level. Peak refers to the built-in peak diode detector used to make the measurement.

"Carrier normal". With this mode, amplitude measurements on RF signals (modulated or unmodulated) may be made using the voltage and dB ranges of the RF AND MODULATION METER.

"Modulation 100". Using this mode the percentage modulation from 0 to 100% of amplitude modulated signals or the frequency deviation from 0 to ± 100 kHz of frequency modulated signal may be measured using the 0 to 10 modulation range of the RF AND MODULATION METER.

"Modulation 30". With this mode the percentage modulation from 0 to 31.5% of amplitude modulated signals or the frequency deviation from 0 to ± 31.5 kHz of frequency modulated signals may be measured using the 0 to 31.5 modulation scale of the RF AND MODULATION METER.

MODULATION:

Two position switch for the selection of the appropriate detector or discriminator for correct demodulation of the signal to be measured. It should be set as follows:

"AM". For measurements on amplitude modulated signals including TV video carriers.

"FM". For measurements on frequency modulated signals.

For unmodulated signals either "AM" or "FM" can be selected.

LOUDSPEAKER:

Volume control for the built-in loudspeaker, controlling the gain of the LF Amplifier of the 2007. A click-stop "Off" position is provided on the control for disconnecting the Audio Amplifier from the supply in order to save power for battery operation.

REF. VOLTAGE:

BNC socket supplying a stabilized 27 MHz reference signal for calibration of the deflection on the RF AND MODULATION METER when the "Ref." mode of the VOLTAGE RANGE switch is selected.

SENS.:

Potentiometer control for adjustment of the internal IF Amplifier gain when the "Ref." mode of the VOLTAGE RANGE switch is selected for calibration of the deflection on the RF AND MODULATION METER.

PROBE INPUT:

BNC input socket for connection of the output plug of the Measurement Probe.

FREQUENCY METER:

A moving coil meter with interchangable meter scales. The scales provided are:
SA 0155. This scale has eight frequency ranges which are calibrated in

MHz to indicate the frequency to which the 2007 is tuned. The ranges are numbered and correspond to those which many be selected with the FREQUENCY RANGE switch.

SA 0156. This scale has eight ranges and is calibrated to indicate the colour as well as the video and audio carrier frequencies of American TV channels. Each of the ranges is numbered and corresponds to those which may be selected using the FREQUENCY RANGE switch.

SA 0157. This scale is similar to SA 0156 except that it is calibrated for European TV channels.

To insert these scales the meter may be released by pushing down and pulling forward the central clip on top of the meter. The meter should then tilt slightly forward enabling the scale already in the meter to be slid out and a new scale to be inserted.

VOLTAGE RANGE:

Stepped attenuator for attenuation in 10 dB steps of the signal to the IF Amplifier of the 2007. The values 0.1 — 0.3 — 1 — 3 — 10 — 30 — 100 marked around the knob are the maximum input voltages (for full scale deflection on the RF AND MODULATION METER) in mV, at the input to the measurement probe for each knob setting. When the 60 dB attenuator is used with Measurement Probe the values are in volts.

If the amplitude of the signal is unknown, use the 100 V knob setting and decrease the attenuation using the switch until a suitable deflection is obtained on the meter. The "Ref." mode of the switch is for calibration of the RF AND MODULATION METER using the internal reference voltage.

BANDWIDTH:

Two position switch governing the selectivity of the 2007.

"Wide". Gives a measurement bandwidth of 200 kHz (within —3 dB limits) for measurements on signals with frequencies above 3 MHz.

"Narrow". Gives a measurement bandwidth of 2 kHz (within —3 dB limits) for measurements requiring a high selectivity.

LIGHT:

Self resetting on-off switch for meter scale illumination when the "Batt." mode of the POWER SWITCH is selected.

TUNING:

Two concentric knobs for coarse (small knob) and fine (large knob) frequency tuning of the 2007 over the range selected using the FREQUENCY RANGE switch. The tuned-in frequency is indicated by the pointer deflection on the FREQUENCY METER.

FREQUENCY RANGE:

Eight position switch for selection of the frequency range over which the 2007 may be tuned using its TUNING control knobs. The ranges are numbered and correspond to the numbers of the frequency or channel ranges on the scale used in the FREQUENCY METER i.e.,

1.	0.1	—	3.0 MHz	5.	50	—	105 MHz
2.	2.5	—	8.0 MHz	6.	100	—	160 MHz
3.	7.0	—	31 MHz	7.	155	—	225 MHz
4.	29	—	55 MHz	8.	220	—	305 MHz

2.3. REAR PANEL OF 2007

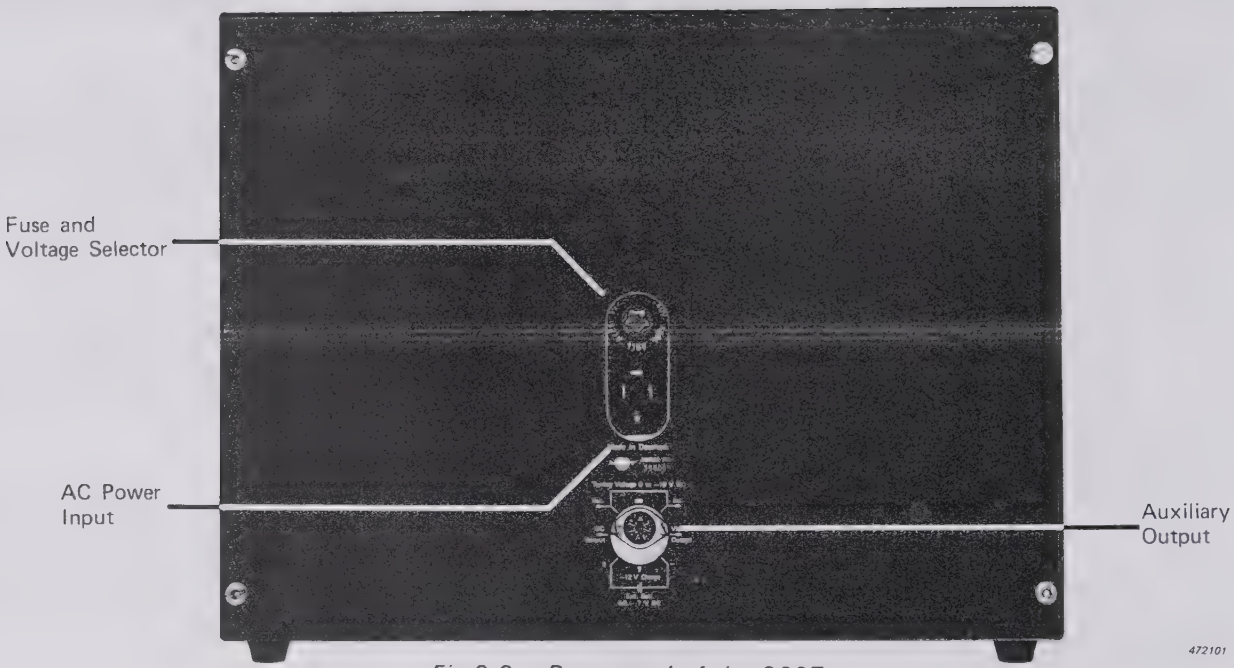

Fig.2.3. Rear panel of the 2007

AC POWER INPUT:

Input socket accepting European or American power cables (B & K Types AN 0005 and AN 0006 respectively) for connection of an AC line or mains supply. The connections to this socket are shown in Fig.2.4.

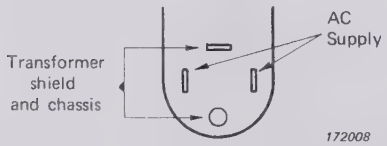

Fig.2.4. AC POWER INPUT

VOLTAGE SELECTOR AND FUSE:

Voltage selector for selection of correct line or mains voltage. The central knob of the selector contains a 250 mA mains fuse, which may be removed by pressing the knob in and turning it counter-clockwise. Half a turn should be sufficient to release the knob, which may then be pulled straight out in order to remove the fuse.

Behind the fuse are some slots. If a coin is pushed into the slots and rotated, the voltage selector will turn. When the white line points to the voltage to be used, the fuse may be replaced and the instrument is ready for use.
NOTE. Verify the line voltage settings before each use.

AUXILIARY OUTPUT:

A seven pin DIN socket accepting a DIN type plug (B & K Type JP 0703) for remote frequency tuning and for connection of external battery supplies to power or to recharge the instrument. It also provides demodulated signal outputs for recording or monitoring purposes. For connections see section 3.4.

3. OPERATION

3.1. PRELIMINARY

3.1.1. The Plastic Protection Cover

On delivery, the front panel of the 2007 is fitted with the plastic protection cover FE 0002, which contains the Measurement Probe and probe accessories of the instrument. To gain access to the front panel controls, the cover may be removed by releasing its two side latches from the fastening slots at the front of the instrument's side panels. For storage of the cover whilst the 2007 is in use, two similar slots are located at the rear of the side panels, enabling the cover to be clamped to the rear panel as shown in Fig.3.1. A cut away section on the bottom lip of the cover permits entry of a power cable for operation of the 2007 with the cover fitted.

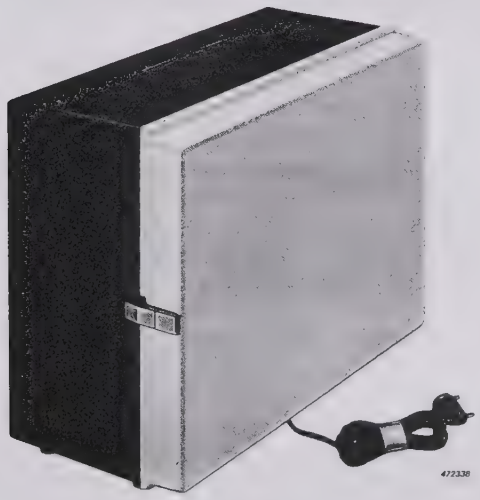

Fig.3.1. The 2007 fitted with the plastic Protection Cover FE 0002

3.1.2. Operation Using a Mains Supply

Voltage Selection

Before each use of the 2007 check that the VOLTAGE SELECTOR on the rear panel of the instrument is set to the voltage of the mains supply about to be used. If not remove the central knob of the selector, containing a 250 mA mains fuse, by simply pressing it in and turning it anticlockwise. Half a turn should be sufficient to release the knob, which may then be pulled straight out. Behind the knob are some slots which, with the aid of a coin may used to turn the selector so that the white line points to the correct voltage indication.

Mains connections

Once the VOLTAGE SELECTOR has been set to the correct mains voltage, the AC POWER socket on the rear panel of the 2007 may be connected to the mains supply using the power cable provided. To power the 2007 from the supply select the "Line" mode of the POWER SWITCH.

3.1.3. Operation Using the Built-in Battery Supply

Selection

To power the 2007 from the built-in battery supply select the "Batt" mode of the POWER SWITCH. The supply contains five rechargeable nickel cadmium cells, which when fully charged give approximately 8 hours of continuous operation.

Meter Scale Illumination

In order to help conserve the charge of the built-in supply, the meter scales of the 2007 are not automatically illuminated when the "Batt" mode is selected. This extends the useful operating life of the supply from 2.5 to 8 hours. However, if scale illumination is required then it may be obtained by pressing the LIGHT push-button on the front panel of the instrument.

Batt Check

Before each use of the built-in supply, it is recommended to check its charge state by selecting the "Batt Check" mode of the POWER SWITCH. A fully charged supply will then be indicated by the pointer of the RF and MODULATION METER registering within the "Batt" region of the scale. If the pointer registers outside the "Batt" region then the supply will need recharging.

Recharging

The 2007 contains a charging unit which may be used to recharge the built-in supply from an external mains or battery supply (for connections see sections 3.1.2. and 3.4.4 respectively) when the "Charge" mode of the POWER SWITCH is selected. For a totally discharged supply the recharge time is approximately 16 hours.

For recharging from a mains supply the "Line" mode of the POWER SWITCH may also be used, if it is required to carry out measurements at the same time.

3.1.4. Replacement of built-in Supply Cells

The Built-in Supply

If after recharging for 16 hours the built-in supply fails to reach a fully charged state, then the nickel cadmium cells of the supply may need replacing. The cells used are SAFT VOLTABLOC Type VR 3.5 (B & K Type QB 0008), which have a voltage and charge rating of 1.2 volt and 3.5 amp hours respectively. SAFT, the cell manufactures, specify that with normal use the cells have a minimum of 300 charge cycles. However, this appears to be a conservative estimate as other manufactures of this type of cell specify that up to 1000 charge cycles are possible.

Removal of Built-in Supply

Before new cells can be inserted, the plug-in housing of the built-in supply, shown in Fig.3.2, must be removed. The housing is located on the top chassis of the 2007 and is accessible when the four retaining screws on the rear panel have been unscrewed and the main cover of the instrument removed.

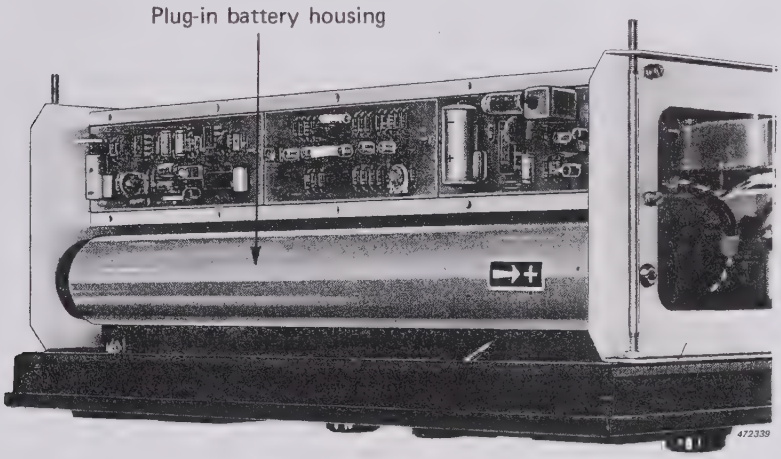

Fig.3.2. The plug-in housing of the built-in supply

To release the housing, push its lower right hand end (as viewed from front panel) towards the left side chassis of the instrument, so that its positive pole clears the locating hole on the right side chassis. The housing may then be lifted clear of the instrument and its contents (five cells, plus a brass contact ring) removed by gradually tilting it, so that its positive pole points upwards. Whilst lifting the housing clear of the 2007, care should be taken not to tilt it too far as its contents could fall into the instrument causing damage.

Fitting New Cells

Before fitting new cells a piece of self adhesive plastic foam (this can be obtained from the cells about to be replaced) should be stuck to the side of each cell. This will ensure that the cells fit snuggly in the plug-in housing and that proper contact is made between them. The new cells may then be slid into the housing after the brass contact ring has been inserted. Care should be taken to ensure that the positive pole of each cell (stud on cell casing) faces the direction indicated on the outside of the plug-in housing.

WARNING

There is a high explosion risk when charging cells which have been fitted incorrectly with their poles reversed.

3.2. CALIBRATION

Before measurements may be carried out, the 2007 should be calibrated using its internal reference voltage.

To do this proced as follows:

1. Carry out the preliminary adjustments necessary (see section 3.1).

2. Fit the FREQUENCY METER with the appropriate frequency or TV channel scale supplied for measurements.

3. Connect the output of the Measurement Probe to the PROBE Input socket of the 2007.

4. Using the screw thread input termination on the body of the Measurement Probe, fit the BNC Connecter JP 0029 (Probe accessory, see Fig.2.1) and plug it into the REF. VOLTAGE socket of the 2007.

5. If not already selected, select the appropriate "Line" or "Batt" supply mode of the POWER SWITCH. The 2007 is transistorized and is ready for use immediately.

6. Set the controls on the 2007 to:

VOLTAGE RANGE	"Ref."
METER SWITCH	"Carrier Normal"
BANDWIDTH	"Wide"
FREQUENCY RANGE	"7.0 — 31" MHz (Range 3)

7. With the SENSITIVITY control turned fully clockwise, adjust the small TUNING knob for coarse frequency tuning until the pointer of the RF AND MODULATION METER deflects to full scale. This should occur when the pointer of the FREQUENCY METER is near to, or coincides with the arrow on range 3 of the meter scale selected.

8. Using the SENSITIVITY control adjust the pointer deflection of the RF AND MODULATION METER to half of full scale and using the small and large TUNING knobs for coarse and fine frequency tuning, adjust the deflection on the meter to peak. Finally adjust the SENSITIVITY control so that the pointer of the RF AND MODULATION METER coincides with the "Ref." mark on the top scale of the meter.

The 2007 is now calibrated for measurements and therefore the Measurement Probe may be disconnected from the REF. VOLTAGE socket.

3.3. CARRIER AND MODULATION MEASUREMENTS

To measure the carrier voltage or the degree of modulation on amplitude or frequency modulated signals, proceed as follows:

1. Carry out the calibration procedure described in section 3.2.

2. Set the controls on the 2007 to:

VOLTAGE RANGE	"100 mV"
METER SWITCH	"Carrier Peak". For amplitude measurements on the video carrier of TV signals. "Carrier Normal". For amplitude measurements on unmodulated or modulated RF signals, other than the video carrier of TV signals.
MODULATION SWITCH	"AM" For measurements on amplitude modulated signals including the video carrier of TV signals. "FM" For measurements on frequency modulated signals, excluding the video carrier of TV signals.

	"AM or FM". For measurements on unmodulated radio frequency signals.
BANDWITH	"Wide". For measurements on AM and FM signals with frequencies from 3 to 305 MHz. "Narrow". For measurements on AM signals with frequencies below 3 MHz. It may also be used for measurements requiring a high degree of selectivity.
FREQUENCY RANGE	As required.

3. Using the screw thread input termination on the body of the Measurement Probe, fit the appropriate test prod, coupler, or termination (see Probe accessories Fig.2.1) for measurements. If the voltage to be measured is unknown or higher than 100 mV use the 60 dB Attenuator. This may also be fitted with one of the probe accessories mentioned. It push-fits onto the body of the Probe when the Probe has first been fitted with a blunt nose test prod, (see Fig.2.1).

4. Apply the signal to be measured to the input of the Measurement Probe or Attenuator.

5. Using the small TUNING knob for coarse frequency tuning, tune the 2007 so that the pointer deflection on the FREQUENCY METER coincides with the frequency or channel of the signal to be measured. The number of the meter scale range to be used for this purpose is the range number to which the FREQUENCY RANGE switch is set. To help location for TV signals, tune to the video region (coloured black) of the channel selected on the TV channel scale. The video carrier normally has a higher degree of modulation than the colour and audio TV carriers and therefore is easiest to locate.

6. To locate the signal, turn the LOUDSPEAKER volume control up and using the small and large TUNING knobs for coarse and fine frequency tuning, tune the 2007 to just below and just above the frequency or video channel selected in item 5. When the signal is located, the pointer of the RF AND MODULATION METER should deflect towards full scale. If the signal is modulated, then the modulation will be heard over the built-in loudspeaker. In the case of a video signal the 50 or 60 Hz synchronizing pulses should be heard. For unmodulated signals a sharp increase in noise should occur. If no signal is detected, or the meter indication is insufficient, turn the VOLTAGE RANGE switch one step counter clockwise and again tune above and below the region of interest. If necessary repeat this process until the signal is located.

7. For TV signals, if the signal to be measured is the colour or audio carrier turn the small TUNING knob clockwise through the frequency of interest. The first signal to be detected (apart from the video carrier) within the channel selected will be the colour carrier (coloured red on the TV channel scales), whilst the second will be the audio carrier (coloured green). If necessary select a more sensitive range using the VOLTAGE RANGE switch, to locate the audio and colour carriers.

8. Having located the signal of interest, adjust the large TUNING knob so that the pointer deflection RF AND MODULATION METER peaks. The pointer deflection on the RF AND MODULATION METER should now indicate between 3 and 10 on the top-most scale of the meter. If not, readjust the VOLTAGE RANGE switch until a reasonable deflection is obtained without overload.

9. The carrier amplitude or degree of modulation may now be read from the RF AND MODULATION METER as follows:

CARRIER AMPLITUDE: Without readjusting the controls of the 2007 the carrier amplitude of modulated or unmodulated signals may now be read directly from one of the appropriate voltage scales of the meter. Full scale deflection on the meter is given by the VOLTAGE RANGE switch setting in mV. If the 60 dB attenuator is used with the Measurement Probe, then the indication is given in volts.

DEGREE OF MODULATION: For modulated signals the degree of modulation may be measured by setting the METER SWITCH to its "Modulation 100" mode and reading off the indication on the 0 to 10 modulation scale of the RF AND MODULATION METER. 10 on the scale corresponds to full scale and represents 100% modulation for amplitude modulated signals or 100 kHz frequency deviation for frequency modulated signals.

If the degree of modulation is below 30% or 30 kHz (i.e., 3 on the 0 to 10 modulation scale) then set the METER SWITCH to its "Modulation 30" mode and read off the indicated value from the 0 to 31.5 modulation scale. In this case 31.5 corresponds to full scale and represents 31.5% modulation or 31.5 kHz frequency deviation.

3.4. AUXILIARY OUTPUT SOCKET

The main uses of the AUXILIARY OUTPUT socket are for connection of control lines for remote voltage controlled tuning of the 2007 and for connection of external battery supplies to power or to recharge the instrument. It also provides demodulated signal outputs for connection of recording or monitoring equipment.

3.4.1. Remote Frequency Tuning

For remote voltage controlled frequency tuning of the 2007, either the built-in supply or an external supply may be used. In either case the internal voltage for coarse frequency

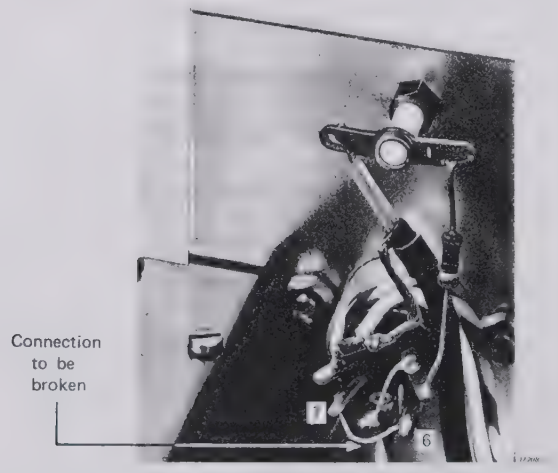

Fig.3.3. Rear view of AUXILIARY OUTPUT socket showing connection between pins 6 and 7, which has to be broken for remote voltage controlled frequency tuning

tuning must first be disconnected from the capacitance diodes of the variable frequency oscillators of the instrument. This can be done by breaking the connection between pins 6 and 7, on the rear of the AUXILIARY OUTPUT socket (see Fig.3.3). The connection is accessible when the four fastening screws on the panel have been unscrewed and the main cover of the instrument has been removed.

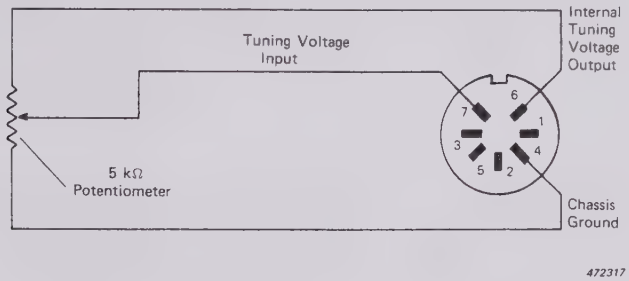

Fig.3.4. External connections to AUXILIARY OUTPUT socket for remote voltage controlled tuning using a potentiometer to regulate an internal supply

Once the internal tuning voltage has been disconnected and the main cover of the 2007 has been replaced, remote tuning may be accomplished by connecting a 5 kΩ potentiometer to the AUXILIARY OUTPUT socket as shown in Fig.3.4 and 3.5. In Fig.3.4, the potentiometer is used to regulate the internal tuning voltage, whilst in Fig.3.5, it is used to regulate an external voltage supply. In both arrangements, once the supply has

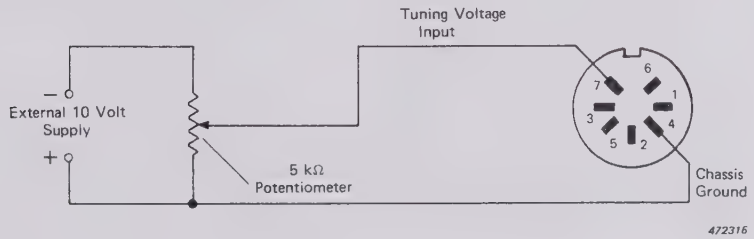

Fig.3.5. External connections to AUXILIARY OUTPUT socket for remote voltage controlled tuning using a potentiometer to regulate an external 10 volt supply

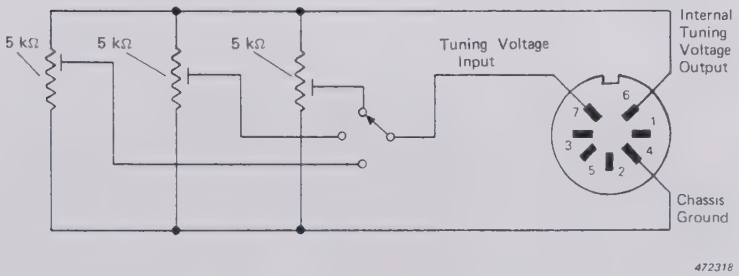

Fig.3.6. External connection to AUXILIARY OUTPUT socket for remote voltage controlled tuning to a number of preselected frequencies using the internal supply and a number of preset potentiometers

been set to —10V (the internal supply can be set to this voltage by turning the small coarse frequency TUNING knob fully clockwise), adjustment of the potentiometer will provide continuous tuning over the entire range of the FREQUENCY RANGE switch mode selected. For fine tuning the fine TUNING control of the 2007 is still operative.

On a similar basis if tuning is required to a number of preselected frequencies then the arrangement shown in Fig.3.6 may be used. In the arrangement the internal tuning voltage is preset to a number of different levels using potentiometers. Frequency selection is then carried out using a switch to select the appropriate potentiometer output.

3.4.2. DC Output

For recording or remote monitoring of measured carrier or modulation levels, a DC Output is taken from the LF Detector of the 2007 and is available at pins 3 and 4 (pin 4 grounded, see Fig.3.7) of the AUXILIARY OUTPUT socket. The output is short circuit protected and has an output impedance of 47 kΩ. Its open circuit output voltage, corresponding to full scale deflection on the RF AND MODULATION METER, is 1.0 volt.

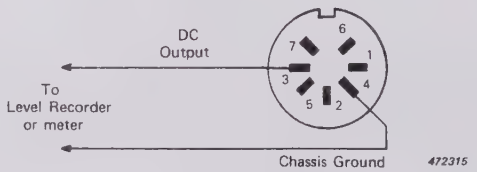

Fig.3.7. DC Output of the AUXILIARY OUTPUT socket

For recording from the DC Output, a Type 2305 or 2307 Level Recorder may be used and the recorder's pen deflection calibrated against the pointer deflection of the RF AND MODULATION METER. Since the input impedance of both the 2305 and 2307 is approximately 18 kΩ, the voltage available for recording from the DC Output will be approximately 275 mV and therefore a 25 dB Range Potentiometer should be fitted to the recorder.

To obtain a remote indication of measured carrier or modulation levels, an external moving coil meter may be connected to the DC Output. The meter should have a 40 μA movement and can be calibrated against the deflection on the RF AND MODULATION METER.

3.4.3. Video Output

For measurements on amplitude modulated signals it is often good practice to check that the carrier envelope of the measured signal has not been distorted by the measurement source. A simple yet reliable way of making this check is to monitor the demodulated wave form of the signal using a low frequency oscillocope connected to the Video Output of the 2007. The output is short circuit protected and has an output impedance of approximately 2 kΩ. It is available at pins 1 and 4 (pin 4 grounded see Fig.3.8) of the AUXILIARY OUTPUT socket.

With the "Carrier" modes of the METER SWITCH selected, the Video Output is DC coupled and is the demodulated output of the AM Detector of the 2007. Because of the DC coupling the signal available at the output consists of a DC as well as an AC

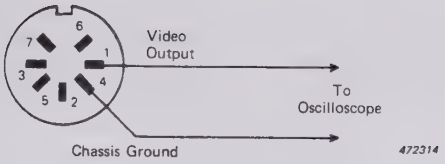

Fig.3.8. Video Output of the AUXILIARY OUTPUT socket

component which represent the respective carrier and modulation components of the measured signal.

For measurements using the "Modulation" modes of the METER SWITCH, the Video Output is AC coupled and is the demodulated output of the AM Detector or the FM Discriminator of the 2007, depending on whether the "AM" or "FM" mode of the MODULATION switch has been selected. In either mode, only the modulation component of the measured signal is applied to the output.

3.4.4. Operation Using External Battery Supply

Recharging

Whilst travelling between measurement sites by car, the built-in supply of the 2007 may be left on charge from the car's own 12 volt battery or from a separate 12 volt accumulator. The necessary connections are shown in Fig.3.9. For cars with a positive chassis steps should be taken to ensure that the metal case of the 2007 does not make contact with any metal panelling in the car as the chassis of the 2007 will become live with respect to the car chassis when the connections are made.

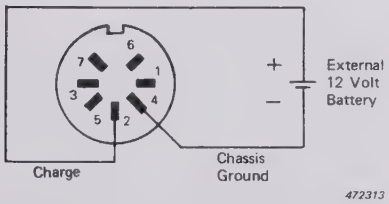

Fig.3.9. Connection of an external 12 volt battery to the AUXILIARY OUTPUT socket for recharging the built-in supply of the 2007

Once the battery connections have been made, the built-in supply of the 2007 will begin to recharge, whatever mode of the POWER SWITCH is selected. However, to obtain a meter indication of the charge state of the built-in supply and to keep current consumption to a minimum (300 mA) the "Charge" mode of the POWER SWITCH should be selected. For a totally discharged supply the approximate recharge time is 16 hours.

Power for Measurements

Before an external battery can be used to power the measurement circuitry of the 2007, the plug-in housing containing the built-in supply must be removed as described in section 3.1.4. Once this has been done and the main cover of the instrument has been

replaced, a battery with a voltage rating of between 5.5. and 7.0 volts may be connected to the AUXILIARY OUTPUT socket as shown in Fig.3.10. To power the measurement circuitry using the battery, select the "Batt" of the POWER SWITCH. The maximum current consumption in this mode is 500 mA.

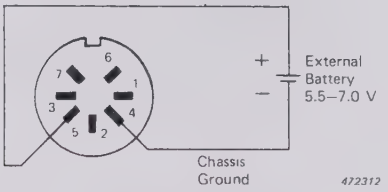

Fig.3.10. Connection of an external 5.5 to 7.0 volt battery to the AUXILIARY OUTPUT socket for powering the measurement circuitry of the 2007

4. DESCRIPTION

The principle of operation of the Heterodyne Voltmeter Type 2007, together with its accessory the Measurement Probe Type ZC 0008, will be described with reference to the block diagram shown in Fig.4.1.

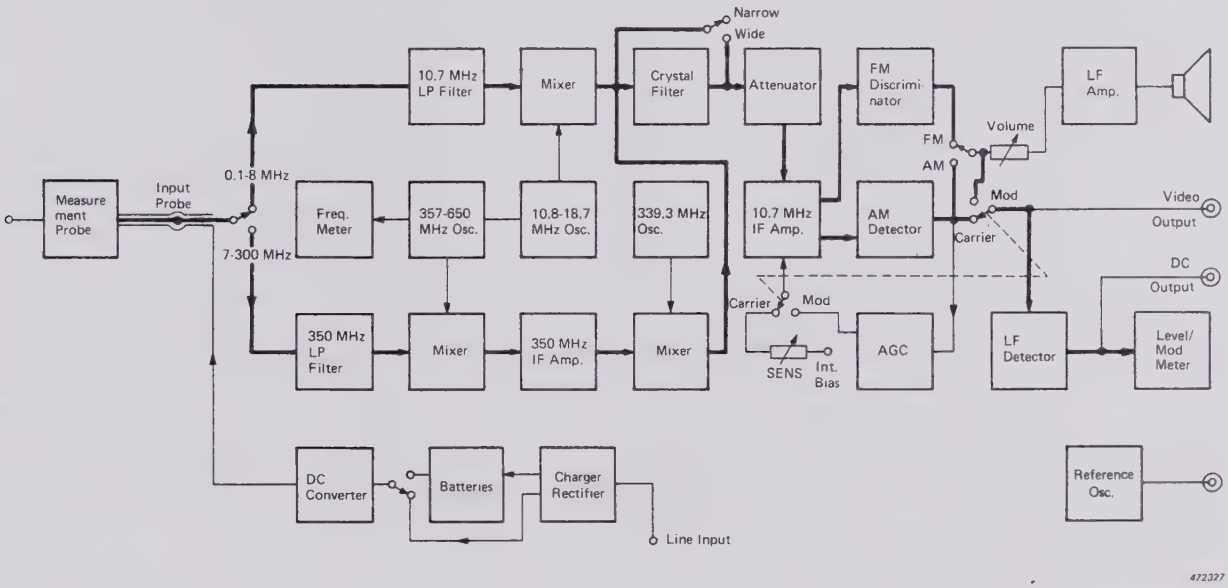

Fig.4.1. Schematic diagram of the Heterodyne Voltmeter Type 2007 together with its Measurement Probe Type ZC 0009

4.1. MEASUREMENT PROBE

The Measurement Probe ZC 0009 is a small easy to handle device with a screw thread input termination accepting the range of accessories shown in Fig.2.1. It contains a miniaturized broad-band preamplifier with a high input impedance FET (field effect transistor) input stage to minimize loading of the measurement source. At 1 MHz the input impedance is greater than 3 MΩ in parallel with 6 pF, decreasing to approximately 20 kΩ in parallel with 6 pF at 100 MHz and to 4 kΩ in parallel with 6 pF at 200 MHz.

The output of the Probe is via a special BNC plug, which fits the PROBE INPUT socket of the 2007. To allow in-situ measurements to be carried out, the preamplifier has a low output impedance enabling a 1.2 m long connecting cable to be used between the body of the Probe and its output plug. Both the cable and plug are an integral part of the probe and carry a supply line from the 2007 to power the probe's preamplifier. To help prevent radiation from affecting measurements, the entire probe assembly including cable is screened.

At frequencies in the 100 kHz to 305 MHz range of the 2007, the maximum input voltage which can be safely applied to the Measurement Probe is 100 mV. This corresponds to the input voltage for full scale deflection on the RF AND MODULATION

METER when the least sensitive voltage measurement range is selected. It can, however, be extended up to 100 volts if the probe is fitted with the 60 dB Attenuator (see probe accessories Fig.2.1) provided. The Attenuator is a capacitive voltage divider, which when used with the Probe has an input impedance of 10 kΩ in parallel with 2 pF at all frequencies up to 305 MHz.

For measurements on biased signals the maximum DC voltage which can safely be applied to the probe or attenuator input is 500 volts. For a 50 to 60 Hz AC bias the maximum input is derated to 250 volts. Extreme care should be taken in applying these types of signals, as if applied suddenly the Measurement Probe could be damaged.

4.2. HETERODYNE VOLTMETER

4.2.1. Input Section

The input to the 2007 for the RF output from the Measurement Probe is via the PROBE INPUT socket of the instrument. In the two FREQUENCY RANGE switch modes covering frequencies from 0.1 to 8.0 MHz, the socket is coupled to a 10.7 MHz Mixer, via a Low Pass Filter with a cut off frequency of 10.7 MHz. In the switch modes covering frequencies from 7.0 to 305 MHz, it is coupled to a 350 MHz Mixer via a Low Pass Filter with a 350 MHz cut off frequency. Within the range of the modes selected, the low pass filter and the input section of the mixer selected have been designed to have an ultra flat frequency response. This overcomes the disadvantage suffered by conventional instrumentation having tuned inputs, which have to be recalibrated at each measurement frequency because of the corresponding "Q" changes of the circuit as the instrument is tuned. With the 2007, however, calibration is necessary at only one frequency using its internal 27 MHz reference signal. Once calibration has been carried out using the reference signal, it is valid at all frequencies in the 0.1 to 305 MHz range of the 2007 and therefore further adjustment is not necessary.

4.2.2. Frequency Selective Section

The frequency selective section of the 2007 is a high quality super heterodyne receiver. In the two FREQUENCY RANGE switch modes covering frequencies from 0.1 to 8.0 MHz, the input signal is mixed with the output of a 10.8 to 18.7 MHz variable frequency oscillator. This heterodynes the input signal component, at the frequency to which the TUNING controls of the 2007 are set, to an IF (Intermediate Frequency) of 10.7 MHz.

In the remaining FREQUENCY RANGE switch modes, covering frequencies from 7.0 to 305 MHz, a 10.7 MHz IF is also used. However, in order to obtain a high image frequency and intermediate frequency rejection (better than —55 dB), as well as a good adjacent channel selectivity, the input signal is heterodyned to this frequency in two stages. First it is mixed with the output of a 357 to 655 MHz variable frequency oscillator to produce a 350 MHz IF signal, which is applied to a 350 MHz bandpass filter (5 MHz bandwidth within —3 dB limits) and IF Amplifier. The required 10.7 MHz IF is then obtained by mixing the 350 MHz signal with output of a 339.3 fixed frequency oscillator.

The fixed and variable frequency oscillators used, are all transistor LC types, which have been designed to have a good frequency stability. Special care has also been taken to obtain a good amplitude stability, thus ensuring that the transconductance of the mixers is kept constant with frequency. As well as conventional types of capacitors the variable frequency oscillators also use voltage dependent capacitance diodes. This enables voltage controlled frequency tuning to be accomplished using the coarse and fine TUNING controls provided to regulate an internal tuning bias applied to the diodes. For remote voltage controlled tuning, control lines are made available at the AUXILIARY OUTPUT socket (see section 3.4).

Following the mixer stages is a crystal filter which is used to obtain a high selectivity. The filter is selected using the "Narrow" mode of the BANDWIDTH switch and gives an IF signal bandwidth of ± 1 kHz. For measurement of input signals with frequencies greater than 3 MHz, a high selectivity is not usually required and therefore the crystal filter may be short circuited using the "Wide" mode the BANDWIDTH selector. In this case the IF signal bandwidth is ± 100 kHz and is bandwidth of the 10.7 MHz IF Amplifier of the 2007. The effective characteristics of both the "Narrow" and "Wide" bandwidth modes are shown in Fig.4.2.

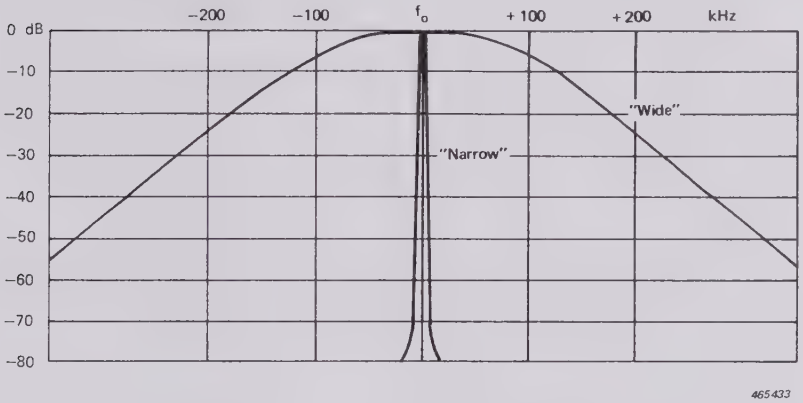

Fig.4.2. Bandwidth of the 2007 when the "Wide" and "Narrow" modes of the BANDWIDTH switch are selected

From the filter, the IF signal is applied to a bank of attenuator networks, which provide up to 60 dB signal attenuation in 10 dB steps. They are selected using the VOLTAGE RANGE switch and give measurement sensitivities ranging from 0.1 to 100 mV for full scale deflection on the RF AND MODULATION METER. If the 60 dB Attenuator is used with the Measurement Probe, then the sensitivity range is from 100 mV to 100 volts full scale.

For amplification of the IF signal, the output from the attenuator networks is applied to a three stage 10.7 mHz IF amplifier with a bandwidth of ± 100 kHz (within —3 dB limits) and a nominal gain of 90 dB. For calibration of the "Carrier" modes, the gain of the amplifier may be adjusted manually using the SENSITIVITY control of the instrument. This regulates the voltage of a fixed bias and applies it to a voltage controlled amplifier and attenuator circuit, which is used as the second stage of the IF Amplifier. The range of adjustment is ± 6 dB.

For modulation measurements, the gain of the IF Amplifier is adjusted automatically. This has the advantage that once calibration has been applied for the "Carrier" modes, the need of a separate calibration for the "Modulation" modes is eliminated. The range of gain adjustment is ± 10 dB and is obtained using the output of an AGC (Automatic Gain Control) circuit to regulate the voltage controlled amplifier. The output produced by the AGC circuit is proportional to the difference between the carrier level of the measured signal (this is derived from the AM Detector output of the 2007) and a reference level corresponding to the carrier level required for full scale deflection on the RF AND MODULATION METER.

4.2.3. Detection and LF Amplification

For carrier measurements with the 2007, the heterodyned output of the IF Amplifier is applied to a simple AM Detector. This rectifies the heterodyned signal, eliminating the

high frequency IF components to produce an output which follows one half of the carrier envelope of the measured signal. The rectified signal is then applied to an LF Detector (Low Frequency Detector), which with the "Carrier Normal" mode of the METER SWITCH selected re-rectifies the signal and averages it to produce an indication on the RF AND MODULATION METER of the "unmodulated" carrier amplitude of the measured AM or FM signal.

For measurements of TV video carriers it is the peak value of the rectified output of the AM Detector which is proportional to the carrier amplitude. For this purpose the METER SWITCH is provided with a "Carrier Peak" mode for converting the LF Detector to a peak diode detector. Because of the large time constant required for peak detection, the peak detector has a differential amplifier input to prevent loading of the AM Detector output. To obtain an indication of the carrier amplitude the output of the detector is coupled directly to the RF AND MODULATION METER which is calibrated to give the RMS value.

For measurements using the "Modulation' modes of the 2007 the AM Detector is again used, but only for measurements of AM signals when the "AM" mode of the MODULATION switch is selected. In this case, the carrier component of the rectified output from the AM Detector is held to a fixed reference level (achieved through the use of automatic gain control on the IF stages), thus making the modulation component of the rectified output proportional to the percentage modulation of the measured AM signal. For an indication of the percentage modulation, both carrier and modulation components are applied to the LF Detector which extracts the modulation component and averages it before applying it to the RF AND MODULATION METER.

For modulation measurements on FM signals, the "FM" mode of the MODULATION SWITCH has to be selected to connect the output of an FM Discriminator to the LF Detector. The discriminator is an integrated balanced product detector, which demodulates the IF signal to produce an output proportional to the frequency deviation of the measured FM signal's carrier. The LF Detector then rectifies and averages the demodulated output before applying it to the RF AND MODULATION METER to give an indication of the frequency deviation in ± kHz.

To facilitate quick and accurate reading of indicated modulation levels, the RF AND MODULATION METER is provided with two ranges. These are selected using the "100% kHz" and "30% kHz" modulation modes of the METER SWITCH and give meter ranges of 0 to 100% (kHz) and 0 to 31.5% (kHz) respectively. The increased sensitivity of the 30% (kHz) mode is obtained by giving the LF Detector a gain of 10 dB in this mode.

The accuracy of the modulation indication is dependent on the MODULATION switch mode selected, as well as the modulation frequency and level. For AM signals with modulation frequencies of 30 Hz to 8 kHz and level of 40%, the accuracy is ± 0.5 dB. This accuracy can also be obtained for FM signals with modulation frequencies from 30 Hz to 40 kHz and a maximum frequency deviation of ± 40 kHz. The linearity for FM measurements is better than 5% of full scale deflection (31.5 kHz or 100 kHz).

To help identify signals on which measurments are to be made, an LF Amplifier and loudspeaker are built-in. These provide an audio output from the AM Detector or FM Discriminator, which may be selected using the MODULATION switch. The maximum power delivered to the speaker by the amplifier is 500 mW and may be controlled using the LOUDSPEAKER volume control.

For external monitoring and recording purposes, demodulated signal outputs are also made available at the AUXILIARY OUTPUT socket of the instrument. These are discussed in section 3.4.

4.3. Power Supply

In order to make the 2007 suitable for field as well as laboratory use, it is provided with "Line" and "Batt" supply modes, which are selected using the POWER SWITCH. With the "Batt" mode selected, power is supplied from five rechargeable nickel cadmium cells. These are built into the 2007 and are contained in a plug-in battery housing. The total supply voltage provided by the cells is 6.75 volts, which is stepped up to —16 volts by a DC converter, before being applied to a voltage regulator to produce a stabilized —10 volts. Both the —16 volts from the converter and the —10 volts from the regulator are then used to power the measurement circuitry of the 2007.

To extend the operating life of the cells to approximately 8 hours, current feed-back is used on the DC Converter to help make its output independent of cell charge. Also the meter scale lamps are disconnected to reduce power consumption in the "Batt" mode. However, if meter scale illumination is required, then the lamps may be reconnected by pressing the self resetting LIGHT push-button on the front panel of the instrument.

For recharging the built-in cells, a charging unit is included. This may be powered from a mains supply or 12 volt car battery and is connected when the "Charge" or "Line" mode of the POWER SWITCH is selected. For mains operation the "Line" mode will be found especially useful as measurements may be carried out whilst the cells are being recharged. For totally discharged cells the recharge time is approximately 16 hours.

For mains operation the 2007 may be operated from any 100— 115— 127— 150— 220— or 240 volt, 50 to 400 Hz mains supply. The correct mains voltage may be selected using the FUSE AND VOLTAGE SELECTOR on the rear panel of the instrument, which connects the supply to the appropriate voltage tap of a mains transformer. The output from two 9.5 volt taps on the transformer is then rectified and applied to the DC converter via a —6 volt voltage regulator.

5. APPLICATIONS

The Heterodyne Voltmeter Type 2007 is designed for selective RF measurements with a high degree of sensitivity and accuracy. Together with its ease of calibration and portability it will be found ideally suitable for measurements, checks or alignment of radio and TV communications equipment, both in the laboratory and in the field.

5.1. ANTENNA DISTRIBUTION SYSTEM MEASUREMENTS

To ensure that the quality of an antenna distribution system is adequate for reception and distribution of radio and TV signals, some performance checks which may easily be made with the 2007 are discussed in the following sections.

5.1.1. Signal Strength and Transmission Loss

The signal strength and transmission loss of an antenna distribution system may be quickly checked using the arrangement shown in Fig.5.1. In this arrangement the input (point A) of the antenna amplifier is disconnected from the antenna and connected to the output of a signal generator. The signal generator is then tuned to a frequency within the range of the antenna system and the signal at the input of the amplifier (point A) and at each cable outlet (point B, C, D, E, F, and G) monitored using the 2007. The gain of the amplifier may then be determined using the relation:

$$A = X_B - X_A \qquad 5.1$$

where A is the gain of the antenna amplifier in dB

X_B is the meter indication in dB, plus the METER RANGE switch setting in dB, when the output signal at point B is measured

and X_A is the meter indication in dB, plus the METER RANGE switch setting in dB when the input signal at point A is measured.

Example

If at the output of an amplifier (point B) a meter indication of + 5 dB is obtained with a VOLTAGE RANGE switch setting of —10 dB and at the input of the amplifier (point A) a meter indication of —3 dB is obtained with a VOLTAGE RANGE switch setting of —30 dB then from equation 5.1 the gain of the amplifier can be determined as follows:

$$A = (5 - 10) - (-3 - 30)$$

$$A = +28\,\text{dB}$$

Using a similar relation to equation 5.1 the transmission loss along the distribution line may be calculated. This is given by:

$$L_X = X_N - X_B \qquad 5.2$$

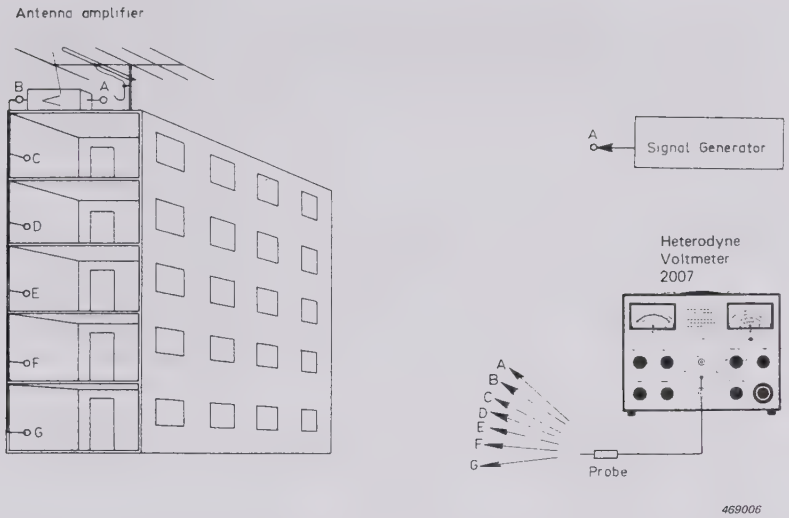

Fig.5.1. Measurement of signal strength and transmission loss on an antenna distribution system

where L_X is the transmission loss along the distribution line in dB
X_N is the meter indication in dB, plus the METER RANGE switch setting in dB when the line output signal at point C, D, E, F or G is measured
and X_B is the meter indication in dB, plus the METER RANGE switch setting in dB when the line input signal at point B is measured.

Note. When making these measurements each of the distribution cable outlets must be loaded with its correct terminating impedance. This can be done by connecting each outlet to a receiver with the correct input impedance. The signal at each outlet may then be measured using the 2007 with its measurement probe connected in parallel with the input of each receiver. If the distribution line is not correctly loaded then standing waves may be set up along the line which could influence the accuracy of measurements.

5.1.2. Cross-Talk Attenuation

A schematic diagram of a typical antenna distribution line is shown in Fig.5.2. The potential divider networks, through which the line outputs are taken, are used to isolate the outputs from each other so as to obtain a high cross-talk attenuation. This is important as it means that the susceptibility of the outputs to loading or local oscillator interference through receivers being connected to other line outputs will be small.

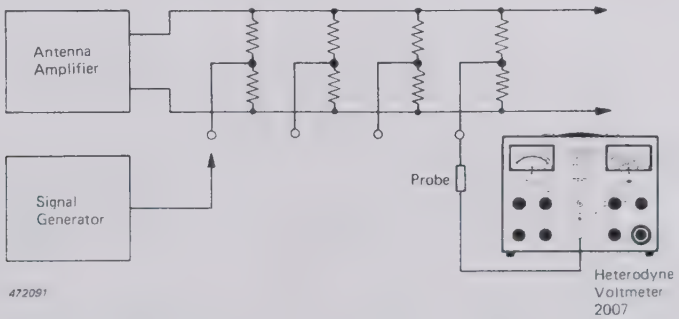

Fig.5.2. Typical distribution line of an antenna distribution system. The 2007 and the signal generator shown are used to measure the cross-talk attenuation of the line

To determine the cross talk attenuation of a line, connect the output of a signal generator to one of the line outputs (see Fig.5.2) and using the 2007, measure the relative amplitudes (in dB) of the input signal at this point and the cross talk signal produced at one of the other line outputs. The cross-talk attenuation may then be calculated using the relation:

$$C_A = X_C - X_I \qquad 5.3$$

where C_A is the cross-talk attenuation in dB
X_C is the sum of the meter indication, plus the VOLTAGE RANGE switch setting in dB when the cross-talk signal is measured
and X_I is the sum of the meter indication plus the VOLTAGE RANGE switch setting when the input signal is measured.

Note. To obtain an accurate measurement the line outputs should be correctly terminated to prevent standing waves from being set up along the line.

5.1.3. Harmonic Distortion

The high selectivity of the 2007, together with its good image and intermediate frequency rejection (more than 50 dB) make it particularly suitable for measurement of distortion in amplifiers. One of the more common types of distortion takes the form of harmonics, which are produced by amplifier non-linearities distorting the fundemental of a signal. These harmonics are produced at odd and even multiples of the fundamental frequency component of the signal, as shown in Fig.5.3.

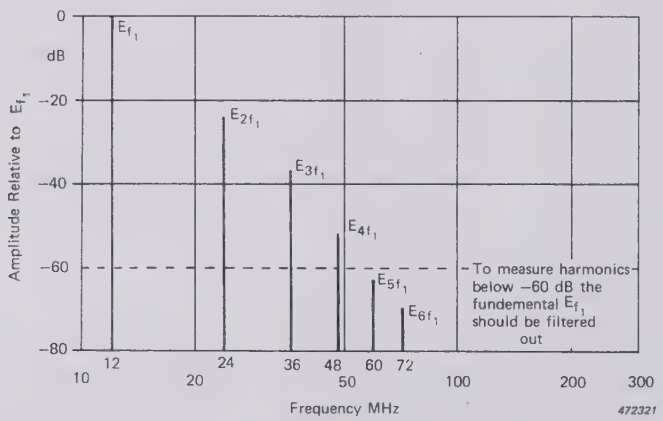

Fig.5.3. Fundamental and harmonic components of a 12 MHz signal

An instrument arrangement whereby the harmonic distortion produced by an antenna distribution amplifier may be determined is shown in Fig.5.4. For measurements, the signal generator is set to produce a sinusoidal output with a frequency within the amplifier's passband where distortion is most likely to occur. The amplitude of the fundamental component of the signal and that of the harmonics produced by the amplifier are then measured separately using the 2007 connected to the output of the amplifier, terminated with the correct load impedance. The distortion can then be calculated using the relation:

$$D_H = \sqrt{\frac{E_{f_2}^2 + E_{f_3}^2 + E_{f_4}^2 + \ldots\ldots E_{f_n}^2}{E_{f_1}^2 + E_{f_2}^2 + E_{f_3}^2 + E_{f_4}^2 + \ldots\ldots E_{f_n}^2}} \times 100\% \qquad 5.4$$

where D_H is the harmonic distortion in %
E_{f_1} is the amplitude of the fundamental in volts
and E_{f_2} to E_{f_n} are the amplitudes of the harmonic components in volts

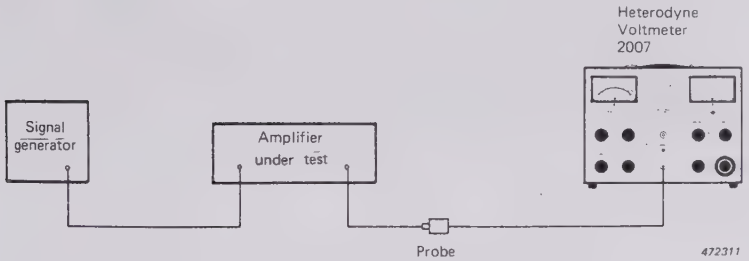

Fig.5.4. Measurement of harmonic distortion

When measuring harmonic distortion at frequencies below 8 MHz, the BANDWIDTH selector must be set to "Narrow" in order to obtain adequate selectivity for the fundamental and harmonic components to be measured separately. It is also important to ensure that the distortion which normally occurs in the input stage of the Measurement Probe does not influence the results. Therefore for measurement of distortion levels down to 5% the amplitude of the fundamental, E_{f_1}, at the input to the Probe should not exceed 31.5 mV (or 31.5 volt at input of the 60 dB Attenuator). Similarly for distortion measurements down to 0.5%, the fundamental input amplitude should not exceed 4 mV (or 4 V at input of the 60 dB Attenuator). For measurement of distortion levels below 0.5%, the fundamental must be filtered out. This can be done by applying the signal to the Measurement Probe input via a high pass filter with a cut off frequency which is adequately higher than the fundamental.

5.1.4 Intermodulation Distortion

It has long been recognized that amplifier non-linearities can produce considerable distortion which may not show up in harmonic distortion measurements. This distortion takes the form of intermodulation of different component frequencies of a signal producing new sum and difference frequencies as shown in Fig.5.5. Since these frequencies are not harmonically related they can seriously impair reproduction of a signal.

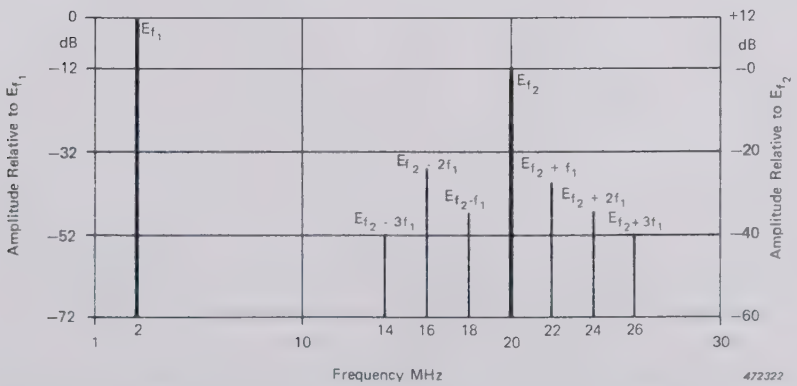

Fig.5.5. Intermodulation components of a 10 MHz signal (E_{f_1}) which is modulated by a 1 MHz signal (E_{f_2}) as a result of amplifier non-linearities

For measuring the intermodulation distortion produced by an antenna distribution amplifier the arrangement shown in Fig.5.6 may be used. In the arrangement the outputs of two signal generators are combined using a hybrid transformer, which applies them via a stepped attenuator to the input of the distribution amplifier. The value of the resistance R_o terminating the transformer is such that the reflected impedance appearing at the input of the attenuator is equal to the attenuator's characteristic impedance, which is chosen to correspond with the input impedance of the amplifier. Similarly the value of the resistance R_L, terminating the output of the amplifier, is chosen to match the amplifier's output impedance.

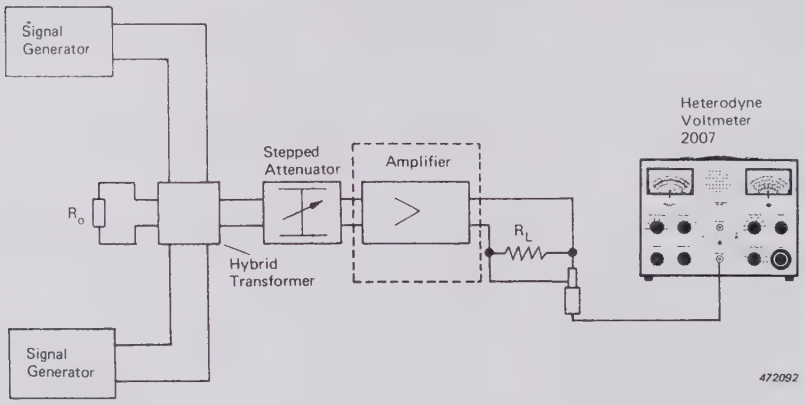

Fig.5.6. Measurement of intermodulation distortion

For measurements, the two signal generators are tuned to two separate frequencies, f_1 and f_2, which are spaced one decade apart ($f_2 / f_1 = 10$) and are within the pass band of the amplifier where distortion is most likely to occur. The outputs from the generators are then set so that the amplitude of the low frequency signal component E_{f_1} is four times the amplitude of the high frequency component E_{f_2}. If non-linearities are present in the amplifier this will cause the component E_{f_1} to modulate the component E_{f_2}, producing intermodulation components at frequencies $f_2 \pm f_1$, $f_2 \pm 2f_1$, and $f_2 \pm 3f_1$ (see Fig.5.5). By measuring the amplitude of each of these components separately, with the 2007 connected to the output of the amplifier, the amount of intermodulation distortion produced can be calculated using the relation:

$$D_{IM} = \sqrt{\frac{(E_{f_2 - f_1} + E_{f_2 + f_1})^2 + (E_{f_2 - 2f_1} + E_{f_2 + 2f_1})^2 + (E_{f_2 - 3f_2} + E_{f_2 + 3f_1})^2}{E_{f_2}}} \times 100\% \qquad 5.5$$

where D_{IM} is the intermodulation distortion in %

E_{f_2} is the amplitude of the high frequency signal component in volts

and $E_{f_1 - f_2}$ etc. are the amplitudes of the individual intermodulation components, also in volts.

Since the amount of intermodulation distortion produced is a function of amplifier output voltage, measurements should be made for a number of different voltage levels. For this purpose the step attenuator in the arrangement may be used to adjust the input signal level to the amplifier. For measurement of distortion down 1%, care should be taken to ensure that the amplitude of the low frequency component E_{f_1} does not exceed 4 mV at the input of the Measurement Probe (4 Volt at the input of the 60 dB Attenuator). For measurements below 1%, E_{f_1} should be filtered out before being applied to the probe.

5.1.5. Sensitivity to Mains Carried Noise

An arrangement whereby the 2007 may be used to check whether the sensitivity of an antenna distribution amplifier to mains carried noise is equal to, or greater than —40 dB is shown in Fig.5.7. In the arrangement the output of a signal generator, tuned to a frequency within the amplifier's passband, is connected via a screened attenuator to the amplifier mains supply. The input to the amplifier is then short circuited and the output (point B) from the amplifier measured using the 2007. This is then compared with the voltage developed at the output (point A) of a second attenuator network, which is connected directly across the output of the signal generator. If the voltage at point B is smaller than at point A then the rejection of mains carried noise is greater than 40 dB.

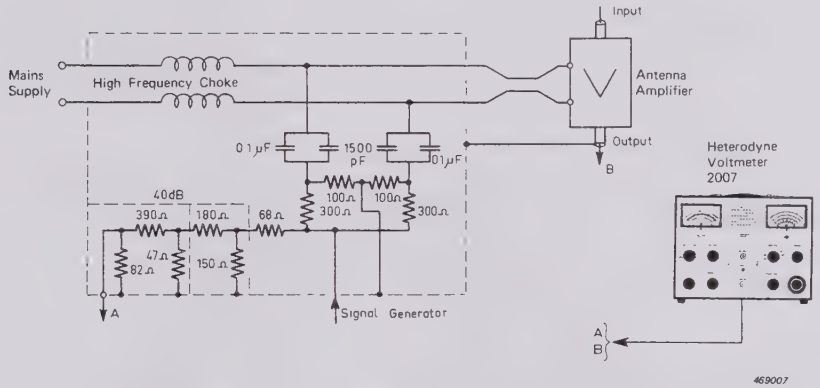

Fig.5.7. Arrangement for checking an amplifier's sensitivity to mains carried noise

5.2. ANTENNA MEASUREMENTS

5.2.1. Use as a Field Strength Meter

If the 2007 is used with a receiving antenna it may be used as a field strength meter. The antenna should be connected to the input of the Measurement Probe of the 2007 using a matched line terminated with an impedance corresponding to the impedance of the antenna. The type of antenna used depends on the frequency or wavelength of the electric field to be measured. For fields with frequencies less than 50 MHz a frame antenna should be employed because of the long wavelengths involved. For fields with frequencies of 50 MHz or more, where wavelengths are relatively short, a split dipole antenna will be found more convenient. This can be made up from two telescopic antenna elements and its overall length set to correspond with the wavelength of the electric field as indicated in Fig.5.8.

For calibration, the antenna should be placed in an electric field with its receiving elements in a horizontal position, 4 metres above ground level. With the 2007 tuned to the frequency of the field, gradually turn the antenna, whilst keeping it horizontal, so that a peak is measured in the deflection on the RF AND MODULATION METER when the "Carrier Normal" mode of the 2007 is selected. If the deflection is insufficient then the measurement sensitivity should be increased using the VOLTAGE RANGE switch. Having obtained a suitable deflection, adjust the SENSITIVITY control so that the RF AND MODULATION METER indicates the strength of the calibrating field. For measurement in other electric fields the 2007 may then be used to give a direct indication of field strength.

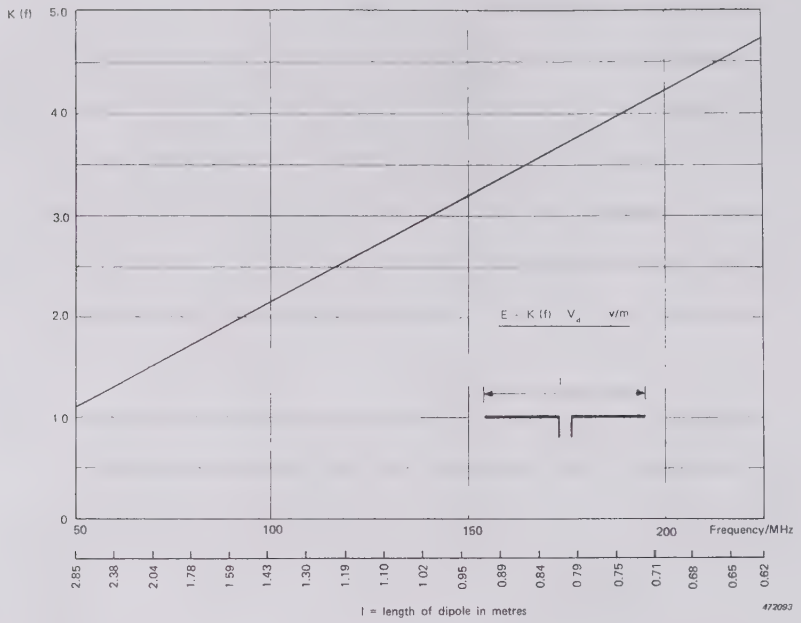

Fig.5.8. Correction factor K(f) for tuned λ/2 dipole antennae

If an electrical field of known strength is not available for calibration, the 2007 should be calibrated for carrier measurements as described in section 3.2. Electric fields may then be measured using the 2007 and the field strength determined by multiplying the RF AND MODULATION METER indication by the correction factor K(f) given in Fig.5.8. The accuracy of the results obtained using this method cannot be expected to be better than ± 3 dB, as the correction factors are based on the assumption that measured fields are homogenous and that the antenna used is ideal. However, for most measurements this accuracy will be found sufficient. The method proves to be both quick and simple to apply, and when the frequency of the field is changed only the correction factor and antenna length need be adjusted.

Using the 2007 as a field strength meter, the directivity of transmitting antennae may be measured. It may also be used to measure the RF radiation produced by radio and television receivers. However, in this case, if more than just a relative measurement is required, it is recommended to consult the IEC (International Electrotechnical Commission) Publication 106-(1959).

5.2.2. Directivity Measurements

Using the instrument arrangement shown in Fig.5.9 the directivity characteristics of receiving antenne may be recorded.

In the arrangement the receiving antenna is mounted on a Type 3921 Turntable and its output connected to the 2007 using the Measurement Probe terminated with a resistance equal to the antenna's line impedance. The Turntable is then synchronized with a Type 2305 or 2307 Level Recorder and the DC Output (see section 3.4.2) of the 2007 with the "Carrier" mode selected is recorded on Polar Chart QP 5102. Provided that the electrical field in which the antenna is situated is kept constant then the recording obtained will be the directivity of the antenna. A typical directivity recording is shown in Fig.5.10.

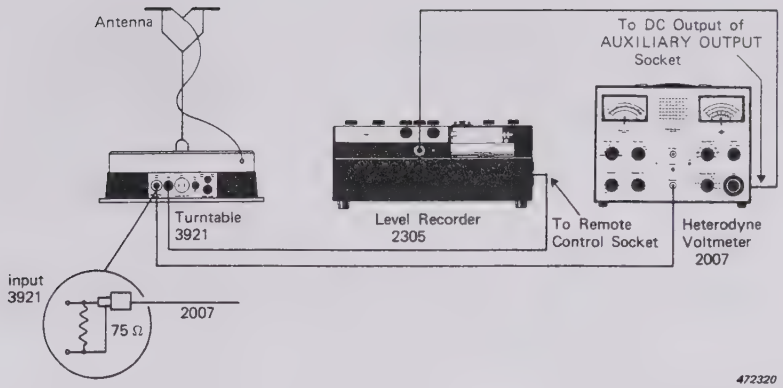

Fig.5.9. Instrument arrangement for recording the directivity characteristics of a receiving antenna

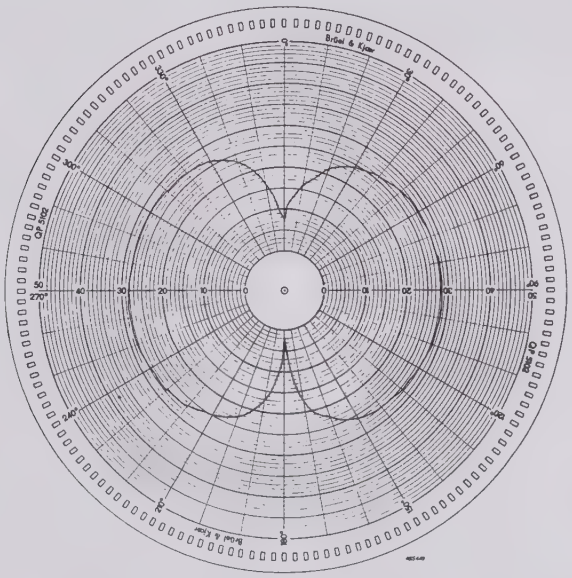

Fig.5.10. Polar diagram of the directivity characteristics of an antenna obtained using the instrument arrangement shown in Fig.5.9

If the field strength is also to be indicated on the directivity recording, then the antenna should be calibrated as described in section 5.2.1.

5.3. SIGNAL GENERATOR MEASUREMENTS

5.3.1. Output Linearity

The high accuracy of the 2007 makes it suitable for checking the amplitude and frequency linearity of the output from a signal generator. A measuring arrangement that may be used for this purpose is shown in Fig.5.11.

In the arrangement, the 2007 is calibrated for measurements using its "Carrier" mode as described in section 3.2. The output of the signal generator is then terminated with its

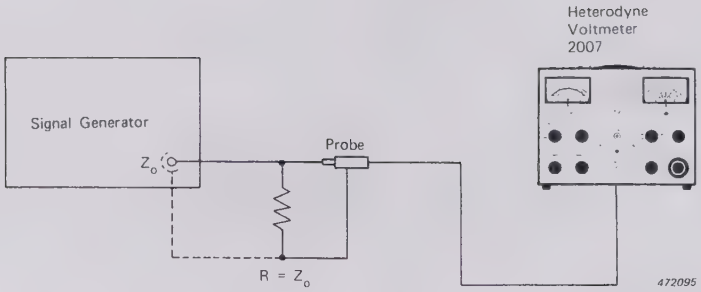

Fig.5.11. Instrument arrangement for checking the output linearity of a signal generator

correct load impedance (this is especially important as a signal generator's output voltage is normally load-dependent) and is connected to the 2007 using the Measurement Probe. For checking the amplitude linearity of the generator's output, both the 2007 and the generator are tuned to one particular frequency and the output voltage indication on both instruments noted for different settings of the generator's output level adjustment. From the results a correction curve similar to that shown in Fig.5.12 may be drawn.

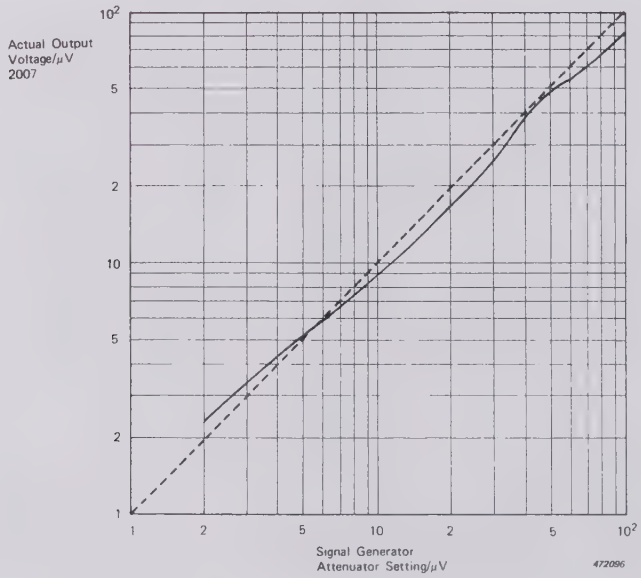

Fig.5.12. Amplifier linearity of a signal generator's output obtained using the arrangement shown in Fig.5.11

The dashed line shown in Fig.5.12 is theoretical and is what would be obtained if the output voltage indication on the generator and that measured by the 2007 were identical. However, in practice a curve similar to that shown by the solid line will be obtained. The deviation between these two lines is the correction which has to be applied to the generator's output voltage indication.

By monitoring the FREQUENCY METER and the RF AND MODULATION METER of the 2007, the instrument arrangement shown in Fig.5.11 may also be used to check the frequency calibration of the generator, and to check whether the amplitude of the generator's output signal remains constant with frequency. In this case the generator's output voltage adjustment is set to give a suitable indication on the 2007 and then the frequency tuning control of the generator adjusted.

Note: The 2007 is a selective voltmeter and therefore for signals other than a pure sine wave it will not give the same reading as an ordinary non-selective voltmeter. This is because a non-selective voltmeter will include the harmonics as well as the fundamental frequency component when measuring the amplitude of a signal.

5.3.2. Modulation Response

An arrangement whereby the modulation response of an AM or FM signal generator may be automatically recorded on frequency calibrated paper using Type 2305 or 2307 Level Recorder is shown in Fig.5.13.

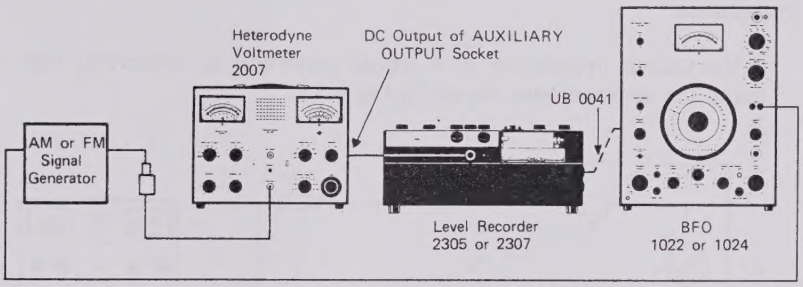

Fig.5.13. Instrument arrangement for recording the modulation response of an AM or FM signal generator

In the arrangement the 10 Hz to 20 kHz output of a Type 1022 or 1024 Beat Frequency Oscillator is used to modulate the output of an AM or FM signal generator, the response of which is to be recorded. The output of the generator is then connected via the Measurement Probe to the 2007 which is calibrated as described in section 3.2. The carrier amplitude of the output from the generator is then set so that the deflection on the RF AND MODULATION METER is within the upper 10 dB of the meter scale, when the "Carrier Normal" mode of the METER SWITCH is selected. For recording, the appropriate modulation mode of the 2007 is selected and its DC Output (see section 3.4.2) connected to the input of the Type 2305 or 2307 Level Recorder, fitted with a 10 to 110 mV Linear Potentiometer and the Recording Paper QP 1124.

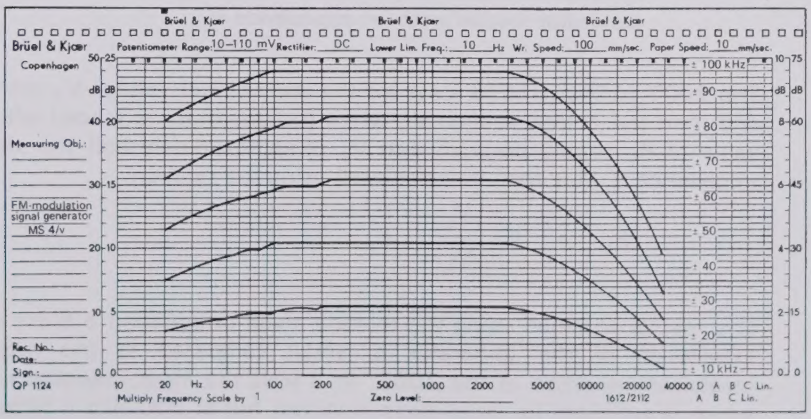

Fig.5.14. Typical modulation response of an FM signal generator obtained using the arrangement shown in Fig.5.13

Synchronization of the frequency graduations of the paper with those of the 1022 or 1024 Beat Frequency Oscillator is then made using Flexible Drive Shaft UB 0041, as described in the instruction manual for the recorder.

For calibration of the arrangement, the INPUT POTENTIOMETER and ATTENUATOR of the level recorder are adjusted so that the recorder pen deflection corresponds to the indication of the RF MODULATION METER when the output of the AM or FM generator is modulated. After calibration a recording of the modulation response of the generator is obtained automatically by pressing the SINGLE CHART-CONT RECORD push button of the recorder. For an FM generator the type of modulation response shown in Fig.5.14 will be obtained.

5.3.3. Output Impedance

If the output impedance of a signal generator is unknown, then it may be determined using the arrangement shown in Fig.5.15.

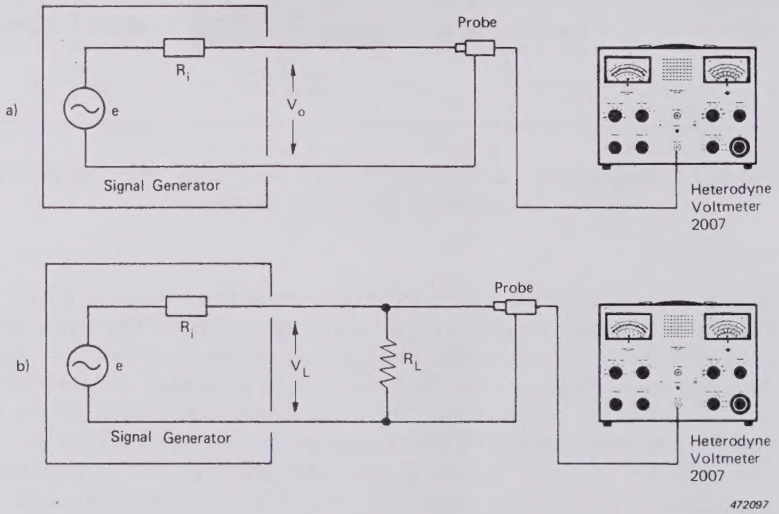

Fig.5.15. Determination of output impedance using the 2007.
a) Measurement of open circuit output voltage V_o of a generator
b) Measurement of output voltage V_L, with output of generator loaded with an impedance R_L

The 2007 is first used to measure the open circuit voltage V_o produced by the generator and then the output voltage V_L when the generator is loaded with a resistance R_L. The value of R_L should be such that V_L is approximately half the value of V_o. The output impedance R_i May then be calculated using the relation:

$$R_i = R_L \frac{V_o}{V_L} - 1 \qquad 5.6$$

The results obtained using the relation given in equation 5.6 are only valid if the output impedance of the generator is small compared to the input impedance of the measurement probe of the 2007. At 1 MHz the input impedance of the probe is 3 MΩ, which is sufficient for most measurements, but at 200 MHz it falls to approximately 4 kΩ. Therefore at higher frequencies it is recommended to use the 60 dB attenuator with the probe which has an input impedance of 10 KΩ at all frequencies. If a still higher input

impedance is required then a resistance should be connected in series with the probe input. In this case, however, the voltages measured using the 2007 will be inaccurate, but since only the ratio of V_o to V_L is of importance in determining the output impedance, the relation given in equation 5.6 may still be used.

Equation 5.6 may also be used for calculating the output impedance of tuned or broadband RF amplifiers. In this case the signal generator is connected to the input of the amplifier and the amplifier's open circuit output voltage V_o and its loaded output voltage V_L measured using the 2007 which has been tuned to the frequency of the signal generator.

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